THE UNIVERSITY OF ALBERTA

RELEASE FORM

NAME OF AUTHOR ALLEN J. CROWLEY

TITLE OF THESIS A COMPARISON OF THE STRAIGHT LINE DEPRECIATION METHOD AND A FILL ADJUSTED SINKING FUND DEPRECIATION METHOD FOR A TELEPHONE UTILITY COMPANY

DEGREE FOR WHICH THESIS WAS PRESENTED M.B.A.

YEAR THIS DEGREE GRANTED 1981

THE UNIVERSITY OF ALBERTA

A COMPARISON OF THE STRAIGHT LINE DEPRECIATION METHOD AND A FILL ADJUSTED SINKING FUND METHOD OF DEPRECIATION ON THE TELEPHONE UTILITY COMPANY

BY

© ALLEN J. CROWLEY

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILMENT OF THE REQUIREMENTS

FOR THE DEGREE OF MASTER OF BUSINESS ADMINISTRATION

FACULTY OF BUSINESS ADMINISTRATION

AND COMMERCE

EDMONTON, ALBERTA

Spring, 1981

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled A COMPARISON OF THE STRAIGHT LINE DEPRECIATION METHOD AND A FILL ADJUSTED SINKING FUND DEPRECIATION METHOD ON A TELEPHONE UTILITY COMPANY submitted by ALLEN J. CROWLEY in partial fulfilment of the requirements for the degree of MASTER OF BUSINESS ADMINISTRATION.

ABSTRACT

The objective of this report is to demonstrate that in most cases, a usage based depreciation method which uses the interest rate in its calculation, in this case titled "Fill Adjusted Sinking Fund Method, (FASFM)" more fairly allocates costs to assets with multi year usefulness than any Straight Line Method, including the Equal Life Group Method.

The intent of this paper is to demonstrate the mechanics of the differences between the methods and to compare them for an actual operating telephone utility.

The stated objectives were fulfilled to the extent that for the subject telephone company, the Fill Adjusted Sinking Fund Method resulted in appreciably different depreciation rates than the standard Straight-Line depreciation method currently being used.

There are several important findings of the study which may have a significant impact on future public utility regulation. Firstly, over a very wide range of growth patterns, the fill adjusted sinking fund method made significantly lower allocations to current years depreciation during times of high growth.

Secondly, the results are very dependent on the rate of fill of assets, with the typical pattern of telephone equipment being particularily susceptible to the discrepancies outlined in the Thesis.

ACKNOWLEDGEMENTS

I which to express my sincere thanks and appreciation to Dr. J. Sprague for his encouragement, advice and guidance, throughout the preparation of my thesis, saving me miles of wandering down blind alleys and illuminating and helping me to enjoy the journey down the productive avenues.

Other people have been of great assistance to me as well. I must first thank my employer, the City of Edmonton, and all the fine people there who assisted in my search for data, especially Ralph Bjerke, Depreciation Engineer at 'edmonton telephones'. I would also like to express my admiration for the late Ron McNeil of Alberta Government Telephones who planted the seeds of this endeavor and Dr. W. Fruehauf of Toronto for suggesting the idea of comparing the two methods for a telephone company. I extend a special thanks to Marlene Chorney and Lori LaFrance for the typing of my manuscript and the many next-to-final drafts thereof.

Lastly, I would like to thank my wife Simonne and our two children Rochelle and Geoffrey for forgiving me the many inconveniences I caused them while I was engaged in this project and for their constant encouragement during my moments of anguish.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

1.0 GENERAL

Life in our modern industrialized society reflects the same pervasive theme of specialization as the process of industrialization itself. Where once each family or small community developed its own systems for provision of the utility services of water, disposal of wastes, heat and communications, now this infrastructure is provided by a small number of specialized institutions.

On another level, even the control of prices, the rationing device for these scarce goods and services, has also been removed from the implicit control of individuals and centralized in specialized bodies.

The apparent advantage of any specialization is that by focusing one's development on a single skill, the level of proficiency in that skill will be higher than if one's energy is spread over the diversity of tasks existent in industrialized society.

For the provision of services themselves, if a single firm is given a guaranteed market, it will theoretically be able to devote its total energy to the continual improvement of service delivery rather than spending some energy on competing for business with other firms. Similarily, for the setting of utility prices, a

regulator with proper authority and training can use all his energy to develop the most appropriate methods for fairly controlling the prices for utility services.

Specialization has been a major factor in improving the standard of living for modern industrialized nations. However, it has one distinct disadvantage. With specialization comes a diminution of the opportunity for spontaneous synthesis of new ideas from across various disciplines, especially if the specialist is trained from the start in only one set of skills.

In a sense, this negative aspect of specialization has also been at work in the regulatory field. The regulation of utilities, built up slowly and progressively into a very complex and precise body of knowledge in the hands of accounting and engineering specialists, has not seen any substantive changes in concept in the last two decades, being largely based on long established systems of accounts and regulatory processes. Perhaps the most significant recent change in regulation is the development of the Equal Life Group Depreciation Method.

This is typical of development in a specialized area. While the Equal Life Group Method is a more precise refinement of earlier actuarial methods, it is stll fundamentally a "Straight Line" Depreciation Method. As with other development in specialized areas, it improves the way something is done but does not ask whether what is being done is, in itself, proper.

This thesis proposes a completely different method of depreciation than the Straight Line Method. To show that it is less myopic than the existing method, the actual role of depreciation is examined in light of the fundamental reasons for regulation. This analysis proceeds in four steps:

1) the reasons for and methods of calculating Depreciation Expense and criteria for evaluating various methods,

2) the role of Depreciation in Utility Regulation,

3) a theoretical model for comparing various methods, and

4) an empirical comparison of two methods.

1.1 DEPRECIATION

Chapter Two begins by describing the mechanisms causing loss of value of capital assets. It then gives accounting, economic and legal reasons for including a calculation of loss of value in the determination of income.

Once the use of depreciation has been justified, one must choose the most appropriate method. This chapter presents various depreciation techniques including the Straight Line Method and the Fill Adjusted Sinking Fund Method (FASFM).

Finally, this Chapter proposes a multi-criteria procedure for determining the best depreciation method, showing that the ultimate choice is dependent on the situation.

1.2 REGULATION

Because the choice of methods is situational, Chapter Three outlines the goals of regulation to show which criteria of choosing the proper depreciation technique should be most heavily weighted in a regulatory environment.

First, the goals of regulation are developed from specific characteristics of a monopoly utility.

Next, the role of Depreciation is examined in terms of its impact on the two major goals of Regulation, 1) economic efficiency and 2) equitable distribution of costs. These two goals correspond to the two typical phases of a regulatory hearing, 1) The setting of "Revenue Requirements" and 2) Rate Design.

This Chapter also presents five practical problems of regulation which are aggravated or mitigated by the choice of depreciation method.

1.3 THEORETICAL MODEL

Chapter Four presents a computer model which is used to show the sensitivity of the two tested depreciation methods to six key

variables:

1) interest rate,
2) service life of the asset,
3) fill profile,
4) growth rate of demand,
5) mortality curve shape, and
6) inflation rate.

By varying each parameter independently, it is easy to see the discrepancy between the two depreciation methods in terms of net income, rate of return, unit price and annual and accumulated depreciation expense.

In all cases, the FASFM Depreciation results in stable prices while the Straight Line Method often introduces very pronounced distortions in price.

1.4 EMPIRICAL MODEL

Chapter Five compares the two methods for a typical utility, 'edmonton telephones'. This process implicitly includes all the effects of the previous chapter, with all the cancelling effects of different values for different variables. Even with these cancelling effects, depreciation expense for the utility, in a period of rapid growth and expansion, is about one-third less using the FASFM Depreciation Method than the Straight Line Method.

This Chapter explains all the simplifying assumptions made and their possible impact on the outcome of the study.

1.5 CONCLUSIONS

The final chapter summarizes the finding of the previous chapters and makes some recommendations for future applications and research in the area of regulatory accounting. Although the results of this study show that the FASFM depreciation is significantly different from the Straight Line Method and theoretically more valid, certain practical problems, including cash-flow changes and other transitional problems, may make a wholesale shift to FASFM infeasible.

At the very least, however, regulators should re-evaluate the time and energy spent on minute refinements of a depreciation method in light of the much larger distortion caused by a fundamental weakness in the whole process.

They should also be aware that traditional depreciation techniques create a large downstream windfall for utilities if rates are not adjusted downwards in times of slower growth or maturing plant.

CHAPTER TWO

DEPRECIATION

> "As surely as humanity travels to the grave, the machinery and equipment of a public utility corporation travel toward the scrap pile. The plant and structures depreciate in less degree but as certainly" [1]

2.0 GENERAL

This chapter will deal with the concept of depreciation as it is generally used in current provincial and federal regulatory jurisdictions. The first section will deal with value and loss of value. The second section will show the relationship between value and depreciation and reasons for depreciaion. The third section will demonstrate various depreciation techniques. The fourth section will outline the criteria for choosing the most "proper" technique from those presented.

2.1 MECHANISMS OF LOSS OF VALUE

It is generally agreed that all assets, except land, lose value with the passage of time. Bryant and Herman[2] and several other authors split this loss of value into two broad categories, physical loss and functional loss.

Physical loss is further categorized by Farris and Sampson into use-related or "wear and tear" deterioration and time-related loss, including corrosion, rot, decay, action of the elements and physical

destruction.[3] While physical loss would appear to be the primary cause of loss of value, it is, in fact, the lesser of the two causes.

By far, the most important cause of loss of value is of the functional type. This is broken down by Farris and Sampson into three broad "factors".[4] The first of these, which encompasses inadequacy due to rapid growth in demand beyond the capacity of the asset, is termed the "market factor".

The second, the "progress factor", accounts for loss of value due to obsolescence, changes in the art and technology (or "supercession" by some authors, including Welsch[5]), changes in customer tastes or depletion of a natural resource serviced by the asset.

The third, the "social factor", causes loss of value by a change in some public requirement, such as pollution control or safety regulations.

The next section will outline the connection between the asset's loss of value and its resultant depreciation.

2.2 REASONS FOR DEPRECIATION

In its strictest sense, depreciation is merely a process of allocating the asset's original cost over the many arbitrarily chosen accounting periods during which the asset will be earning revenue.

Although one cannot argue that the function of depreciation is allocation rather than valuation, it will be shown later that in a regulatory setting, it is most "proper" that the pattern of allocation be as close as possible to the pattern of loss in service value over the life of the asset.

The language generally used in Federal and Provincial legislation defines depreciation as;

> "the loss of service value not restored by current maintenance, incurred in connection with the consumption or prospective retirement of (an asset) from causes which are known to be in current operation and against which the utility is not protected by insurance".[6]

Although, in general, all costs of purchasing an asset are encountered before an asset is put into service, there are sound reasons for performing an allocation of costs to the various years during which it provides service. These are discussed below in the categories of accounting, economic and legal reasons.

2.2.1 Accounting

Luper[7] outlines various categories of "Generally Acceptable Accounting Principles (GAAP)", including, in the category of "persuasive" principles,- those broad starting premises which are intuitively reasonable - three concepts which are directly related to depreciation:

1) Recognition of Expense

2) Association of expense with revenue on the basis of cause and effect

3) Systematic and rational allocation

Gordon and Shillinglaw[8] and others refer to this idea alternatively as the "matching" concept. If an asset generates revenues over several years, the concept would suggest that expenses should also be allocated over that period.

The result of this allocation would be to mitigate the discontinuities caused by a large cash outlay followed by several years of net cash-inflow. Some uniform allocation would cause all net incomes to be roughly equal in each year of the asset's life.

2.2.2 <u>Economic</u>

Allocation is also of value for economic reasons. If all costs were charged against the first year of the product's life, and yearly rates were based on costs, as they generally are in the regulatory environment, the first year of an asset would see the imposition of inordinately high rates. As will be demonstrated later in this chapter, these rates would preclude the optimal level of allocation of consumer resources to that commodity.

Because current regulatory rating practices are heavily influenced by depreciation expense, the more closely depreciation expense

approaches the true periodic cost of the asset, the more optimally resources will be allocated.

2.2.3 Legal

From a legal perspective, regulatory law is designed to insure fair and reasonable rates to the customer and a reasonable rate of return to the owner of the Utility. Although the Utility is now legally entitled to the orderly recovery of the cost of assets used to provide service to the customer, this right was not always so clearly upheld. Terborgh recalls,

> "In the Civil War Income Tax Law, depreciation was not even mentioned. In the act of 1894 (ruled unconstitutional in 1895), it was expressly disallowed. It was not until the third venture into the field, in the Corporate Income Tax Act of 1909 (nominally an excise), that the propriety of capital consumption charges was recognized. That Act permitted a reasonable allowance for the depreciation of property".[9]

It is interesting to note that it was in the same year, 1909, that the Supreme Court first recognized depreciation as a proper charge in the regulation of public utility rates.

> "Before coming to the question of profits at all, the company is entitled to earn a sufficient sum annually to provide not only for current repairs, but for making good the depreciation and replacing the parts of the property when they come to the end of their life. The company is not bound to see its property gradually wasted without making provision out of its earnings for

> its replacement. It is entitled to see that from earnings the value of the property invested is kept unimpaired, so that, at the end of any given term of years, the original investment remains as it was in the beginning. It is not only the right but the duty to its bond and stockholders, and, in the case of a public service corporation, at least its plain duty, to the Public." *(Knoxville V. Knoxville Water Co. 212 U.S. 1, 53 L.ed 371, 29, Sup. Ct. 148)*[10]

In some cases, an alternate defense was also used, namely the argument of "illegal confiscation". As outlined by Spurr:

> "Confiscation may take place in various ways. It may be accomplished by undervaluing a utility company's property as well as by allowing an insufficient return upon a proper value or rate base *(Bonbright V. Geary, 210, Fed 44; Pacific Gas & E.Co. v. San Francisco, 265 U.S. 403, 68L.ed 1075, P.U.R. 1924D, 817, 44 Sup. Ct. Rep 537.)* or by an insufficient allowance for depreciation or depletion *(Re United Fuel and Gas Co. (W.Va) P.U.R. 1924A, 357)"*.[11]

Once having established the accounting, economic and legal reasons, one must choose, from various alternatives, the depreciation technique which most adequately conforms to these reasons.

2.3 DEPRECIATION TECHNIQUES

Over the years, many methods of doing the depreciation allocation have been put forward. Several techniques are presented in two broad categories, Straight Line Techniques and Other Techniques.

2.3.1 Straight Line Techniques

This section reviews the mechanics of depreciation for a single asset. Further refinements of Straight Line Depreciation Method for dealing with "mass properties", namely the Vintage Group Method and the Equal Life Group Method are presented in detail in Chapter Four.

Because of its simplicity, Straight Line Depreciation is currently the most widely used depreciation technique for regulated companies. It relates the depreciation expense strictly to the passage of time. By graphing the charge per period, the accumulated depreciation and the undepreciated asset cost against time, one can see the straight lines which give the technique its name. (See Figure 2.1).

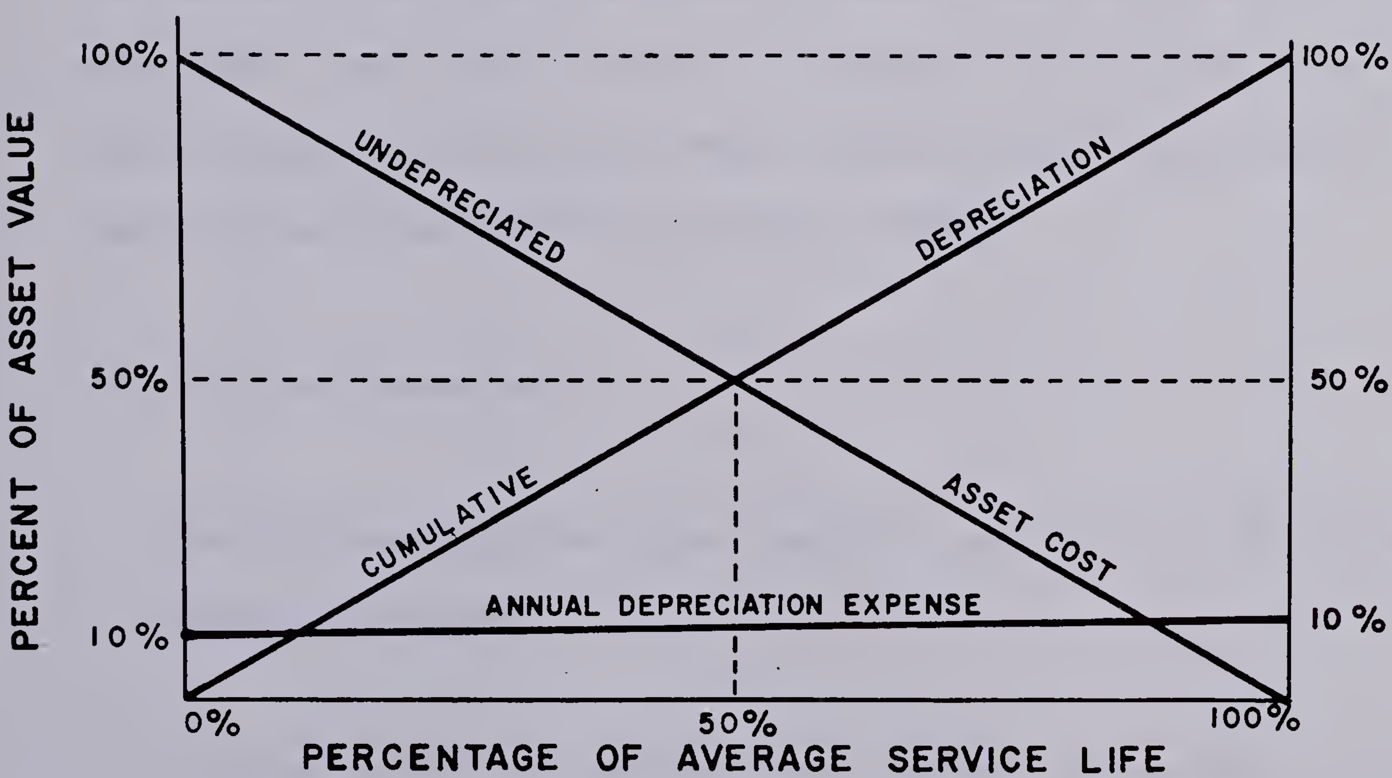


Figure 2.1

Typical Straight Line Depreciation Expense
Ten Year Service Life

Straight line depreciation is calculated by dividing the total loss in value by the estimated years of service of the asset, as in the formula below:

$$Dn = \frac{Co - Sn}{n}$$

where
Dn = Depreciation expense in year n

Co = Capital Cost in year o
Sn = Salvage Value in year n
n = Service life

$$= \frac{1100 - 100}{10}$$

Example:
Co = \$1,100
Sn = \$100
n = 10 years

$$Dn = \$100$$

2.3.2 Other Methods

The methods shown below are three in number; one based on Units of Production, one which reflects the concept of the "Time Value of Money" (Sinking Fund) and one which combines both of these features, the "Fill Adjusted Sinking Fund Method (FASFM)"

1) Units of Production.

The 1965 Depreciation Guide describes the Units of Production Method as follows:

> "The Units of Production method, prorating depreciation on the basis of the number of units produced, is widely used in determining depreciation of equipment used in mines, oil wells, and forests. The computation is comparable to that of depletion.

> By dividing the cost or other basis, less estimated salvage value, by the estimated number of units to be produced during the life of the asset, a unit depreciation factor is obtained which when multiplied by the units produced during a given year, gives the depreciation sustained for that year."[12]

For example, suppose an asset with a value of $10,000 had a service life of five years, in which it produced outputs as shown in Table 2.1.

Table 2.1

Calculation of Units of Production Depreciation Expense (Co = $10,000)

a	b	c	d
Year	Output	Ratio (B/400)	Depreciation (C x $10,100)
1	20	.050	$500
2	30	.075	750
3	40	.125	1250
4	100	.250	2500
5	200	.500	5000
TOTAL	400	1.000	$10,000

The Units of Production Method would allocate part of the $10,000 of capital to the first year, in the ratio of the first year's production (20 units) to the total production (400 units) or .050 (ie. 20/400) of the total amount, to yield a depreciation expense for that year of $500 (ie. $10,000 x .050).

This method conforms more closely to the Accounting Principle of "matching" expenses to revenues than the Straight Line Method.

2) Sinking Fund Method

The second Non-Straight Line method is called Sinking Fund Depreciation. Sinking Fund Depreciation is calculated in two steps.

First, having estimated three characteristics of the asset, namely:

a) the capital cost,

b) service life, and

c) the expected discount rate,

the capital cost is spread out as a series of annuities by the formula:

$$a = \frac{i(1 + i)^{n}}{(1 + i)^{n} - 1} \times Co$$

where :

a = annuity

i = discount rate

Co = Capital cost of the asset

n = service life.

This annuity would be equivalent to the series of equal periodic withdrawals which would just exhaust a bank account starting at a balance of \$ Co and earning i % per period, compounded periodically, on the outstanding balance.

For example, say a five year asset, costing \$10,000, was

expected to earn a 10% internal rate of return. The annuity each year would be \$2,637.97 as calculated below:

$$a = \frac{i(1+i)^n}{(1+i)^n - 1} \times Co$$

$$a = \frac{(0.1)(1.1)^5}{(1.1)^5 - 1} \times \$10{,}000$$

$$a = \$2{,}637.97$$

Next, for each year, the present worth of all cash-flows subsequent to that year is calculated. The resultant loss of value from year to year is the Sinking Fund Depreciation.

The present worth at each year (j) would be calculated as the sum of all cash flows subsequent to that year by the formula:

$$PW_j = \sum_{m=j}^{n} \frac{a}{(1+i)^{m-j-1}}$$

Where PW_j = Present Worth of all cash flows subsequent to year j
n = Service Life
i = discount rate
a = annuity (eg. \$2,637.97)

For example, the present worth of the stream at year 0 would be the sum of each of the revenue flows brought back to time zero by its respective Present Worth factor (see Table 2.2 below). As expected, its Present Worth is \$10,000.

Table 2.2

Present Worth of Cash Flows at Time 0
(i=10%)

a	b	c	d
Year	Annuity	PW factor	Present Worth
(n)	(a)	$\frac{1}{(1+i)^n}$	(b x c)
1	2,637.96	.9091	$2,398.16
2	2,637.97	.8265	2,180.14
3	2,637.97	.7513	1,981.95
4	2,637.97	.6830	1,801.77
5	2,637.97	.6209	1,637.98
Cumulative			$10,000.00

At each successive year, the stream could be revalued as the sum of all cash-flows after that point in time. Graphically, it could be represented as in Figure 2.2.

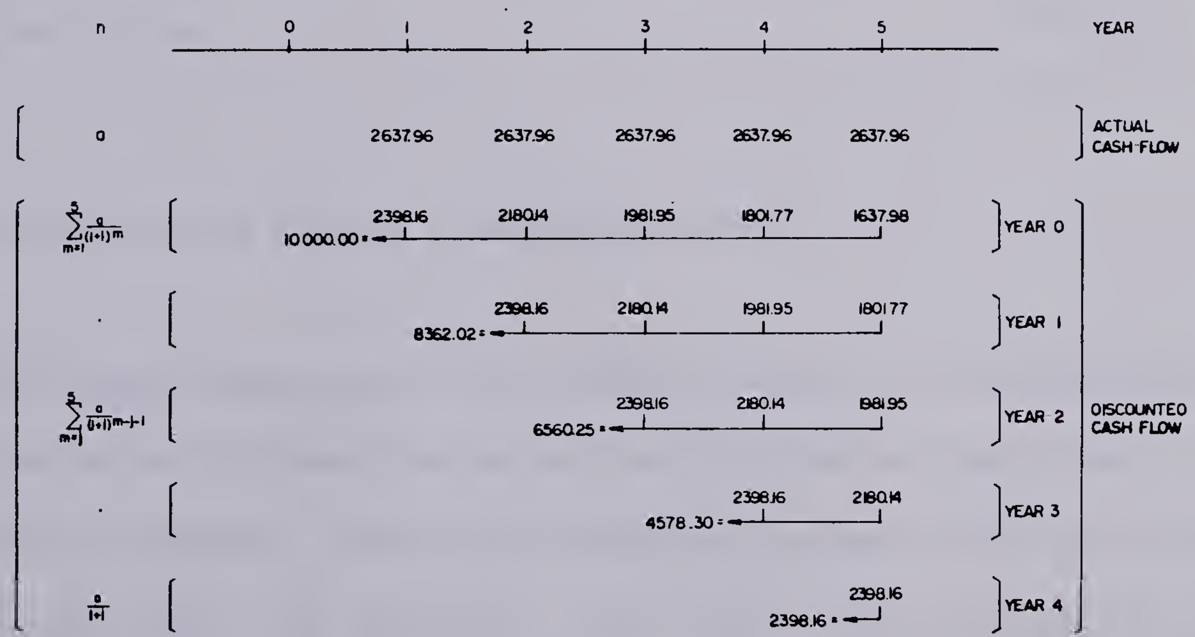


Figure 2.2

Graphic Representation of Successive
Present Worth of Cash Flows

Therefore, the loss of value from year 0 to year 1 would be calculated as the difference between \$10,000 and \$8,362.02, or \$1,637.98. Each successive year could be calculated in a similar fashion as in Table 2.3 below. This is the Sinking Fund Method.

Table 2.3

Calculation of Loss of Economic Value

a	b	c	d
n	PW_{n-1}	PW_n	$PW_{n-1}-PW_n$
			(b-c)
1	10,000.00	8,362.02	1,637.98
2	8,362.02	6,560.25	1,801.77
3	6,560.25	4,578.30	1,981.95
4	4,578.30	2,398.16	2,180.14
5	2,398.16	0.00	2,398.16
Cumulative			10,000.00

3) Fill Adjusted Sinking Fund Method (FASFM).

The third Non-Straight Line Method, FASFM, is a combination of the Units of Production Method and the Sinking Fund Method. In this procedure, rather than assuming the asset will have equal cash-flows, the expected cash flows for each period are estimated as though each unit would earn an equal amount. This amount would be at such a level so as to just amortize the

capital cost over the asset's life. This is accomplished in three steps. First, the asset's characteristics must be estimated. Three characteristics are as required for the Sinking Fund Method, namely:

a) Capital Cost,

b) Service Life, and

c) Discount Rate

and the fourth is as required for the Units of Production method,

d) Units Produced, by year.

Next, one calculates the "present worth of unit years" of output by discounting the number of customers each year into a "time equivalent" number of customers at time zero. The sum of these numbers is divided into the total capital cost and the quotient will be the revenue required from each unit to exactly pay back the capital cost, plus interest on the outstanding balance.

To illustrate this, suppose an asset provides service to customers as outlined in Table 2.4. The corresponding present worth (PW) of customers is calculated and totalled to 273.03 PW customer years. The $10,000 capital cost would be shared as $36.63 (ie. 10,000/273.03) by each customer year.

Table 2.4

Calculation of Present Worth Customer Years
(i=10%)

Year	Customers	PW Factor	PW Customer Years
1	20	.9091	18.18
2	30	.8264	24.79
3	50	.7513	37.57
4	100	.6830	68.30
5	200	.6209	124.20
Total	400		273.03

By multiplying the $36.63 per customer year by the respective number of customers in each year, one could calculate a cash-flow and a resultant loss of economic value for each year. (See Table 2.5)

Table 2.5

Summary of Cash Flows

Year	1	2	3	4	5
Units	20	30	50	100	200
Cash flow (Units x $36.63)	732.53	1098.79	1831.32	3662.65	7325.29

If one were to calculate the Present Worth of this revenue stream at year 0, it would be $10,000, (See Table 2.6).

Table 2.6

Present Worth of Revenue Stream at Time 0 (i=10%)

a	b	c	d
Year n	Cash-flow	P.W. Factor	P.W. of Cash flow (bxc)
1	732.53	.9091	665.94
2	1098.79	.8264	908.09
3	1831.32	.7513	1375.90
4	3662.65	.6830	2501.64
5	7325.29	.6209	4548.43
TOTAL			10000.00

If this same operation were conducted for each successive year, the results, shown graphically below, would be:

Figure 2.3

Cash Flow Diagram

Therefore, the loss of value from year 0 to year 1, would be the difference between \$10,000 and \$10,267.46 or -267.46. Each successive year could be calculated in a similar fashion (see Table 2.7, below). Column d would be the FASFM depreciation expense.

Table 2.7

Calculation of Loss of Economic Value

a	b	c	d
Year n	PW^{n-1}	PW^{n}	$PW^{n-1} - PW^{n}$
1	10,000.00	10,267.46	-267.46
2	10,267.46	10,195.42	72.04
3	10,195.42	9,383.64	811.78
4	9,383.64	6,659.35	2,724.29
5	6,659.35	0.00	6,659.35
Total			10,000.00

It is interesting to note that in this example, the asset actually has a negative depreciation expense in year 1. This is intuitively correct since the earnings in year 1 (\$732.53) were less than the interest of (\$10,000 x 10%) = \$1,000. Therefore, once this year of apparent loss is over, the asset is actually more valuable. This anomaly is created by the choice of a particularly drastic hypothetical fill pattern but it could conceivably reoccur in the utility field on very large assets with slow fill histories.

2.4 CHOOSING THE PROPER TECHNIQUE

2.4.1 General

In the previous section, various depreciation techniques were presented but no attempt was made to choose the most proper one. This section presents and evaluates several different selection criteria and then uses them to determine the most proper technique.

Even the decision of what criterion to use must rest on the uses to which the depreciation calculations will be put. As Coughlan states,

> "It is frequently stated that the ideal depreciation calculation should determine the one true figure that will serve all purposes. This book supports the contrary view. To be of any practical use, the determination of depreciation should serve as a fundamental data source leading to intelligent decision making and ultimate action. The determination of depreciation should therefore be influenced by the sort of action that is contemplated."[13]

Grant goes on to expand on the situational aspects of determining the appropriate depreciation technique,

> "There is no one right method for distributing the differences between the first cost of a fixed asset and its salvage value among the years of its life. The best that can be done is to develop criteria for judging the merits of alternative methods and then note which methods correspond best to those criteria"[14]

Selection criteria can be split into two types:

1) Pragmatic
2) Normative

The pragmatic criteria evaluate practical reasons for preferring one method while the normative criteria are theoretical ideals against which a particular method can be compared.

Although a cursory evaluation of the validity of each criteria is presented, Chapter Three, Regulation, will more fully illustrate which of these criteria should be most heavily weighted when making the final decision on the appropriate technique in a regulatory environment.

2.4.1 Pragmatic Criteria

Lambden[15] suggests a possible structure for selection criteria, consisting of three levels of screening, each pre-emptive, in the sense that each level leaves a reduced number to be considered by the next. These levels are termed:

1) constraining criteria,
2) tailoring criteria, and
3) implementing criteria.

1) Constraining criteria.

Lambden proposes seven criteria which effectively rule out any methods which do not meet certain conditions:

"a) Should be possible to specify, unambiguously, and in advance, the method used and to defend that choice against all competing alternatives.

b) The method should divide up what is available, no more, no less, the results should be additive.

c) Allocate a depreciable base defined in terms of historical cost.

d) Are systematic rather than discretionary.

e) Are rational, that is, based on internally consistent reasoning.

f) Provide for periodic charges to expense rather than lump sum write-offs.

g) Allocate the depreciable base of an asset over its estimated life."[16]

2) Tailoring Criteria.

These criteria specify objectives as per Accounting Principles Board Statement No. 4 (Paragraphs 85-109). these include:

a) Relevancy

This criterion suggests that the technique have a degree of accuracy consistent with the accuracy of estimates used in the calculation and with the detail of decision being made because of the information. As will be shown in Chapter Three, the magnitude of the depreciation expense, both in absolute terms and as a percentage of total expense, would require that the deprecation expense calculation be as precise as possible. In fact, when weighed against the cost of preparing depreciation expense figures and analyzing them

at Rate Hearings, minor fluctuations in depreciation methods will make relatively large changes in depreciation expense.

b) Comparability

Depreciation is a major determinant of net income. In order to make the financial reports of one company comparable to those of another, it is valuable to have some commonality of method across companies. In the Canadian Telecommunications Industry the Straight-Line Method (ELG&VG) is used almost exclusively. This Straight-Line preference has been studied in other industries as well. The Conference Board, in 1969, conducted a survey of 229 companies which revealed the popularity of using Straight-Line methods for financial reporting compared to accelerated methods for Income Tax purposes. (see Table 2.8).

Table 2.8

How Depreciation Methods are Used

Method	Reporting Purposes	Tax Purposes
Straight-Line	125	15
Sum of Digits	12	28
Declining Balance	11	57
Combination of Methods or other Methods	81	129
Total	229	229

Source: Industrial Week[17]

The preference for the Straight Line Method is not common to all industries. However, as Bennett states,

> "Of the three methods used in calculating depreciation, the sinking fund method is the most widely used in the real estate industry, one of the few industries that finds this method so popular."[18]

c) Neutrality

Also referred to as objectivity by some authors, this criterion states, as Welsch suggests,

> "To the fullest extent possible, accounting data must be supported by formal and verifiable business documents originating outside the entity. Under this principle, opinions, estimates and judgemental decisions should be kept to a minimum consistent with the necessities of the situation."[19]

It cannot be disputed that the Straight-Line Method epitomizes neutrality. Aside from minor fluctuations, as theorized in the Lorenz-Einstein transformations,[20] time passes, inevitably and consistently, without regard to the biases of individual accountants. However, even the Straight-Line Method requires an estimate of the ultimate service life. More will be said about the requirements and limitations of making estimates in the section on Normative criteria.

3) Implementing Criteria.

Once the methods have passed the two levels of screening, this step chooses a method consistent with the specific situation. For example, suppose empirical observation showed that:

a) Events contributing to exhaustion of assets subject to high risk of obsolescence have greater incidence in earlier years.

b) All other assets became exhausted according to intensity of use.

Then the specific implementing criteria could be:

a) Assets subject to high risk should be depreciatied by accelerated methods.

b) All other assets should be depreciated by the straight-line method.

Besides the three levels of criteria suggested by Lambden, the following are the three other important pragmatic criteria:

4) Simplicity

While simplicity is a noble attribute to strive for, its

appropriateness as a criterion for choosing a proper depreciation rate can best be summed up by Welsch,

> "Although the straight-line method is simple and widely used, it is appropriate as a method of cost allocation only where conditions are such that a logical matching of costs and revenues results from its use. If the level of output is essentially the same from period to period, the straight-line method is appropriate. In situations where the economic service potential of the asset decreases primarily as a result of the passage of time, as might be the case where obsolescence is the primary factor, the method is appropriate; however, simplicity can hardly be viewed as a primary criterion of suitability."[21]

Of course, simplicity can be applied to more than one aspect of depreciation. As Baxter notes,

> "Depreciation methods that recognize cost of capital sound complex but they can simplify the analysis of results. Thus they help to make profits comparable where the methods of financing differ. They help to make comparable also the successive years' rates of return on investment. With cruder methods, these rates tend to look higher each year."[22]

Similarly, Johnson suggests that,

> "Its use (time-adjusted method) would free analysts from the necessity of making complex though crude approximations to book yields when comparing diversions, companies, industries or even one

company over time."[23]

Friedman makes a strong point by comparing the evaluation of a company to the decision of investing in a bond,

> "(It is) vital to have a realistic and correct return on investment rather than a distorted meaningless figure in order to evaluate performance."[24]

5) Conservatism.

An old accounting principle, conservatism suggests that the accountant, whenever he must make an estimate, do so as not to overstate the wealth of the company, Bonbright gives his blessing to the practice,

> "One may properly give weight to the criterion of conservatism from the standpoint of corporation finance. This criterion suggests thus, as between two proposed methods of cost amortization, one of which undertakes faster write-offs than the other during the early years of useful service lives, any reasonable doubt may well be resolved in favor of the former, unless in consequence, the resulting temporarily higher rate levels will be a serious detriment to the development of a demand for utility services commensurate with plant capacity".[25]

Of course, as in all of the constraints, the principle of conservatism must be tempered so as not to materially distort the accounted wealth of the company. In fact, Friedman judges

on the weight of this criterion with respect to the annuity method, as follows,

> "One can see that the annuity method is not conservative in the case of a long-lived building, because a large portion of the building cost is deferred until the last few years of its life - the time when uncertainty as to the value of the asset is greatest. In the author's eyes, this lack of conservatism in not allocating the cost evenly over the life of the asset is the main objection to the annuity method by accountants in the United States; this is probably more objectional from a theoretical standpoint than a practical one"[26]

2.4.2 Normative Criteria

In this section, four areas of critera will be discussed:

1) accounting,
2) economic,
3) mathematical, and
4) estimation requirements.

The term "normative" suggests that the criteria are based on ideals and concepts rather than practical considerations. The first one, Accounting, shows that the general principles of accounting as pronounced in Generally Accepted Accounting Principles can themselves be used as ideals which are more or less closely conformed to by each method.

1) Accounting

In this section, criteria will be presented in three areas:

a) Matching concept.

b) Cost concept

c) Decision Making Orientation

a) Matching

The matching concept requires that expenses be charged against the revenues for which they were incurred. There are several methods for doing this matching. The highest level of conformance would be achieved by the method which achieved the best matching. Although the "CICA Terminology for Accountants", states that depreciation is,

> "an accounting procedure in which the cost or other recorded value of a fixed asset less estimated salvage (if any) is distributed over its estimated useful life in a systematic and rational manner. It is a process of allocation not valuation." (Emphasis added)[27]

By introducing the concept of matching, the apparent dichotomy between allocation and valuation is implicitly challenged.

Contrast Malchman with Burt. Malchman suggests,

> "The process of recording depreciation gives recognition to the loss of asset value through

> use. Depreciation is not a process of valuation; ie, its objective is not to report the asset at the amount at which it could be sold at anytime because the asset was not acquired for purposes of resale. That method should be selected which is practical and meaningful to the user."[28]

However, Burt takes the opposite stance,

> "The purpose of this paper is to expose ... common ground and to reconcile many apparent incongruities by showing that there is a certain duality between the 'valuation of assets' approach and the income 'measurement approach' to depreciation."[29]

Bullock suggests that traditional accounting principles may have been misguided,

> "We should recognize that generally accepted accounting principles for productive property have been valid largely because they approximated the desired result, rather than because they were inherently correct"[30]

It is precisely because the Straight Line Method does not inherently match revenues and expenses correctly that the other methods were developed.

One of the other stated methods, the Units of Production technique, improves the quality of this matching of expenses to revenues through the use of an intermediate measure, namely output. This refinement, to some extent, reflects

the propensity of some assets to lose value in proportion to usage. Welsh makes an interesting comparison between straight-line and Unit of Production methods in relation to choosing the most proper method,

> "it may be appropriate to note the effect on total cost of products and on unit product cost of the methods discussed. The straight-line method results in depreciation as a cost of being reported as a fixed cost in total but variable per unit of output. In contrast, the ... productive output method would result in depreciation as a cost being reported as variable in total, but fixed per unit of output ... These distinctions are particularly important in cost analyses for managerial pricing, control, and decision-making considerations. These relative effects should be considered carefully in selecting a method of depreciation for each tangible fixed asset"[31]

The most conforming of all methods would have a direct connection between revenues and expenses. Johnson unequivocably argues in favor of such a method,

> "'Matching' in this conventional sense will mean that the same cost to net revenue ratio prevails in every period of assets' life. More specifically, the 'matching principle' means that the ratio of any year's depreciation allowance to acquistion cost must equal the ratio of that same year's net revenue to the total net revenue expected over the asset's life."[32]

He goes on to say, later,

> "But if depreciation expense is independent of revenue, then the cost/net revenue nexus is broken, and the economic analysis becomes an absurdity... Observations of physical deterioration and frequency distributions of physical life can never be more than proxies for estimating the expected economic benefits. Without a rational relationship between costs and net revenues, depreciation is capricious mismatching.
>
> Non-matching of costs and revenues might be adopted for income tax benefits, but it should not be used for book reporting to stockholders if one purpose of financial reports is an accurate communication of economic events"[33]

So if Johnson is to be believed, as far as this criterion is used to judge, the Straight-Line Method is the least conforming, while one based on units produced is better and one based on proportion of revenues in each year is the most proper.

b) Cost Concept

In this section, we will see what constitutes the cost of depreciation and how it affects how costs should be allocated. The key issue here is the impact of the cost of money on the choice of depreciation technique. Vatter argues,

> "The time value of money is a basic fact of life, and its cost is a real cost... Accounting theory and practice cannot be built or used in a piecemeal fashion. The structure must be complete, and its application consistent.
>
> A consistent use of this viewpoint would exclude conventional depreciation from acceptable accounting practice"[34]

Similarly, Bullock feels that return on the asset must be reflected in the depreciation system,

> "In addition to the original cost, which generally must be charged to expense as depreciation, the enterprise is committed:
>
> 1) to operating expenses
> 2) to interest...
> 3) to a sought after return on equity...
>
> Each unit of production must bear its share of the committed cost; including committed return. Since the timing and amounts of productivity and costs are factors in the decision to acquire property, they should also be factors in accounting. For proper matching of costs and to reflect economic reality, the combined revenue requirements should be recognized in proportion to productivity, and the return component should be recognized in proportion to net investment."[35]

This does not suggest that we put the cost of money into the depreciation expense but merely that we recognize that the same revenues and expenses occurring at different times reflect a different cost to the company and should be

treated accordingly. For this particular criterion, then, only interest adjusted methods conform.

c) Decision - Making Orientation

In their quest for criteria to judge the appropriateness of depreciation methods, several authors go back to the fundamental reason for accounting, namely, to provide decision-making information to various users. These users will be analyzed in three categories:

i) Company officials
ii) Existing and Potential Investors
iii) Regulatory agencies

i) Company officials

Good managers are constantly evaluating whether to add or delete parts of their organization. As Goldschmidt states,

> "Suppose that at the beginning of the period the assets employed by a segment are valued close to their replacement cost and that at the end of the period reported income of the segment is high. The high level of income is a signal for management to investigate the source of the high income and to consider whether any actions are appropriate."[36]

It would be more useful if this information were in a form which did not require a great deal of interpretation to arrive at a proper answer. As Bierman judges our conventional systems,

> "Measuring the efficiency of the utilization of assets is not an easy task even with the simplest of assumptions. Ideally, the measure of efficiency should be consistent with the objectives of the firm and not interfere with the attempt to attain these objectives by distorting decision making. Normal depreciation procedures result in such distortion"[37]

The mechanisms of this distortion revolve around the pattern of rate of return on investment caused by various depreciation methods.

Countless authors have demonstrated the tendency of straight-line depreciation to understate early life rate of return and then overstate it in the later part of the asset's life. Friedman describes it as a "definite problem with Straight-Line Depreciation.[38] This effect will be exhaustively demonstrated in Chapter Four.

Johnson poses a problem,

> "A fundamental task for accounting theorists is to determine whether the purpose of

> accounting is best served by a constant rate of return on net revenue or by some other depreciation method."[39]

Sosnick suggest a general guiding answer to Johnson's question,

> "The principle objective in charging depreciation should be to translate capital outlays into current costs in such a way that no change occurs in reported net earnings if no "real" change occurs in business position"[40]

Bennett is more specific and suggests an appropriate type of depreciation,

> "1. In the context of income producing property, it is the anticipated yield which forms the basis for the decision as to whether or not to invest in the property. This yield is based on the cash flow generated after taking into account all charges, including interest and principal payments but not depreciation, and it is therefore unrealistic and unfair to depress reported net income in the early years solely by reasons of high depreciation and high debt costs.
>
> 2. When the cost of property is met largely from borrowings, it is the aggregate of depreciation and interest costs that have to be received from the life of the property and, since debt will decrease as mortgage principal is repaid, a reverse trend in the

> depreciation process will achieve a relatively constant rate of return."[41]

Similarly, Reynolds supports a depreciation system which gives a constant return on investment,

> "Entrepreneurs do not ... buy future net services at 'face' or 'par' - they buy the asset to make a profit; hence, conceptually, they discount the bundles of future net services which they purchase. Therefore, by inference, an ideal depreciation method, is one which allocates costs in such a way as to produce a uniform return on remaining unamortized investment in all periods at the rate of return implicit in the original transaction by which the asset was acquired."[42]

So management needs an accounting system and particularly a depreciation technique which makes decision-making easier and more accurate by reflecting cost of money in the depreciation system.

ii) Investors

This problem of distortion of return is not viewed as much of a problem for investment decision, according to Horwitz,

> "Several earlier studies on depreciation switching have concluded that the market 'is not fooled' when cash flow changes are not a variable. They have indicated that stock

> market prices are relatively unaffected by switches in depreciation methods that increased earnings per share. Our conclusion ... is in accordance with the previous studies on depreciation switches."[43]

Nevertheless, if, as he suggests, depreciation is not important for investment decisions, it could only help if depreciation were consistent with proper investment decision making.

iii) Regulatory Agencies

Unlike investor decision making, regulatory decision making is deeply affected by the depreciation method. Graham states,

> "For public utilities, a much more important issue hinges on the choice between (depreciation) bases. In this, a non-competitive, regulated industry, the selling price of the service is dependent on the choice of depreciation bases...
>
> In a regulated industry, the issue is much more than the selection of a method of showing profit; it is a vital factor in the determination of the service rate - the selling price of the product or service. Hence arguments which might prevail in competitive enterprise purely on a basis of accounting practice must be allowed no

> weight in the public utility field where a 'fair' price for the service is the primary issue"[44]

Graham, after presenting the resultant rates which were suggested by several depreciation techniques concludes,

> "It is evident from the figures above that under the conditions assumed, a constant periodic service charge (in terms of purchasing power) for continued use of a specific asset can best be secured by computing depreciation by the compound-interest or sinking fund method."[45]

In the regulatory environment, where price is the final output of decision making, Graham's conclusion has great intuitive appeal. In times of no inflation, his proposal suggests that for a single asset utility, a unit of consumption of service from that asset should cost every user the same amount, not just in any year but at any time during the life of that asset. This should be, for the regulator, the single most important criteria of the "properness" of a depreciation method and is used by the author henceforth in that context.

One other objective of accounting, as outlined by the Accounting Principles Board[46] is "to account for a transaction in conformity with its economic substance". This leads us to the next category of normative criteria.

2) Economics

This set of criteria uses, as a measure of conformance, the degree to which the depreciation method results in the reflection of "economic substance" of depreciation. This issue will also be addressed in Chapter Four in the use of depreciation for rate design.

In the Pragmatic section under the heading of "Matching", some pragmatic reasons were given for upholding the dual role of depreciation, as a process of allocation and evaluation. This same cause can be defended for normative reasons as well.

The idea of using the expected loss of economic value as a basis for depreciation has had a glowing history of advocates and antagonists. As early as 1921, in the Elizabethtown v. Elizabethtown Water Co.[47] case, a type of compound interest method was discussed as a possible method of depreciation. Even at that time the standard argument against this method was based on the empirical difference between "economic value and market value".

Market value can be determined exactly at the beginning of an assets' life by its purchase price and at the end of its life by its selling price. Information is not as available, however, to determine the time pattern of the market value between those two points of time. It could be defined theoretically as the price the market place would be willing to pay for the asset if it was

offered for sale at anytime.

On the other hand, "economic value" of an asset is the present value or capitalization of all subsequent income expected to be generated by the asset during its lifetime. Because "market value" and "economic value" may not have the same time pattern, both the accountant and the regulator have been reluctant to choose between them. Most practitioners of both fields have avoided the choice of "value" by ignoring it and opting for a depreciation method which required no such subjective judgements.

However, probably the most insightful solution was put forward by Edwards who reduced the theoretical difference between them to a problem of market inefficiencies by stating,

> "If the machine had a single use and all single enterprise firms who employ the machine were equally efficient, arbitrage between the new machine and used machine markets would tend to bring market values into conformity with the computed investment (economic value) figures. Under these circumstances market depreciation and internal rate depreciation would yield the same pattern over time."[48]

Even if there were no practical problems associated with equating the depreciation allocation to economic valuation, accountants might still need some justification of this principle. Several authors have suggested that it will result

in a more optimal allocation of resources. For example, Johnson proposes the following:

> "If the purpose of accounting is to assist in the efficient allocation of economic resources, then depreciation theory must be based on economic theory. Since industries and firms have different capital/labor ratios, the return on assets is more relevant for resource allocation than the return on revenue. Economic theory presumes that the time-adjusted method is theoretically superior to conventional depreciation for allocating costs."[49]

Baxter states a similar argument from a slightly different viewpoint,

> "Cost of capital has important social implications. An alert community will want its capital to be used in the most fruitful way, and may reasonably insist that company accounts give an assurance of this point. (Not having this information), enables slack or selfish management to invest beyond the point at which yield is adequate... and has made it difficult for shareholders in high cost companies to shift their capital and cut their losses, and leave the production of the commodity to those firms which are more efficient"[50]

Lancaster states substantially the same theorem in more formal economic terms. Specifically for the public sector,

> "Since public goods lie outside the market system, there is no simple mechanism like the price system to determine the appropriate mix of public and private goods. Once society has chosen (by whatever means) its preference between all possible combinations of public and private goods, however,

> the standard conditions for optimality in production apply. The marginal rate of transformation between public and private goods is equal to their marginal rate of substitution in social welfare: and to ensure being on the production possibility curve, the ratio of the marginal products of the two factors should be the same in the production of public goods as in the production of private goods."[51]

So, the proper choice of depreciation technique, where price is based on that calculation, becomes a matter of social concern in the sense of optimality of resource allocation rather than purely from the standpoint of fairness. That is, its justification can rest equally soundly on purely altruistic reasons or practical reasons. This unity of justification can be expanded to a unity of another kind.

3) Mathematical

This section, while very brief, points out an areas where the proposed FASFM has a strong intuitive appeal over the other methods. Albert Einstein was always striving for a more unified, general theory of mass, energy, gravity, magnetism and electricity, often being led intuitively by his desire to choose the most general theory. This same generality creates an intuitive appeal for the proposed FASFM depreciation method.

Consider two characteristics which separate the methods:

a) fill profile, and

b) implied discount rate.

It is interesting to note that for certain assumptions about the values of these two variables, each method produces the same depreciation expense and price pattern as the FASFM. For example, the Straight-Line, Units of Production and Sinking Fund Methods are all the same as the FASFM if the discount rate is zero and the fill profile is constant over time. If the interest rate is non-zero, but the fill is still constant, the Sinking Fund Method alone is the same as the FASFM. All combinations are shown in Table 2.9. Only the FASFM produces a uniform price over the life of the asset for all the specific cases.

Table 2.9

Comparison of Generality of Various Depreciation Methods

Interest (i)	Fill Profile Constant	Fill Profile Not Constant
$i = o$	SL UOP SF FASFM*	UOP FASFM*
$i \neq o$	SF FASFM*	FASFM*

<u>LEGEND</u>

SL = Straight Line
UOP = Unit of Production
SF = Sinking Fund
FASFM = Fill Adjusted Sinking Fund Method

4) Requirement for estimate

One of the pragmatic criterion suggested above was that of "Simplicity". This criterion is an extension of that earlier one, but it was purposefully deferred until the rest of the Normative criteria were expanded upon. This section is intended to show that many authors feel the normative aspects of a proper technique outweigh the pragmatic ones. First of all, as Johnson points out, all methods require some prediction,

> "The difficulty and uncertainty of predicting net revenues cannot be cited as a theoretical justification for rejecting time-adjusted depreciation in favor of conventional depreciation since the latter also requires the prediction of revenues."[52]

Secondly, the estimate will usually be better than the implicit estimate of not estimating, or as Stelzer more clearly puts it,

> "it is surely unreasonable to favor an arbitrary measure of cost over an inexact measure...Because we cannot see the future clearly does not mean we should close our eyes to it.[53]

Baxter relays a similar feeling and, in fact, uses the same metaphor as Stelzer,

> "The difficulties of measuring cost-of-capital are no justification for shutting ones eyes to its effects. A manager who chooses zero percent as his rate may know that the true figure could perhaps be 7 percent or 13 percent, nevertheless, calculations based on 10 percent are more likely to lead him to sound decisions than if he treats the rate as zero percent."[54]

In any event, good managers should have already made estimates of fill and interest in order to properly conduct economic interval studies. These same estimates should also be used later to evaluate the progress of projects. It is actually in the very errors we fear that management is best served by methods with "economic substance", as Friedman suggests,

> "Furthermore, it should be recognized that when the actual cash flows of a period differ from the expected cash flows, the annuity method presents no problems. Higher than expected cash flows would be recorded as higher than expected return on investment for the period in which the variation occurred, whereas lower than expected cash flows would be recorded as a lower than expected return for that period. These deviations from expectations should be of most interest to the ... investor because he can see the impact of a change in cash flows on this return on investment ratios. When the cash flows return to the level originally predicted, so will return on investment."[55]

So the requirement for estimates may not be a great constraint when evaluating different depreciation techniques. In fact, one should be cautious when using a method which asks us to forecast too little.

2.5 SUMMARY

Many criteria have been suggested in two categories, Pragmatic and Normative. They have varying degrees of importance. Similarly, each method has varying degrees of compliance with these criteria. Several authors suggest that there is not one proper method but that the choice of depreciation method is situational, dependent on the adjudicator's specific criteria.

This chapter can be summarized in Tabular form (see Table 2.10). The first column describes the criterion. The second column shows the author's rating of the importance of the criterion (H = High, M = Medium, L = Low). Following these two, there is a column for each of the four proposed methods, resulting in a matrix of the scores of each method for each criterion. Within the perspective of a regulated public utility, which is laid out in the next chapter, the situational requirements of the depreciation method indicate a strong weighting on those criteria which favor the Fill Adjusted Sinking Fund Method.

Table 2.10

Conformance Matrix of Selected Criteria for Four Depreciation Methods

Description of Criterion	Importance of Criterion	Straight Line Method	Units of Production	Sinking Fund	FASFM
A. Pragmatic					
1. Constraining					
a. Specific	L	H	H	H	H
b. Divide exactly	H	H	H	H	H*
c. Allocate historical cost	L	H	H	H	H
d. Systematic	H	M	M	M	H*
e. Rational	H	L	M	M	H*
f. Periodic	L	H	H	H	H
g. Over estimated life	L	H	H	H	H
2. Tailoring					
a. Relevancy	L	H	H	H	H
b. Comparability					
- other telcos	L	H	L	M	L
- over-time	L	L	M	M	H
c. Neutrality	L	H	H	M	M
3. Implementing	L	L	L	L	L
4. Simplicity					
a. Creation	L	H	M	M	L
b. Evaluation	M	L	M	M	H
5. Conservatism	L	H	L	H	L
B. Normative					
1. Accounting					
a. Matching Concept	H	L	M	M	H*
b. Cost Concept	H	L	L	M	H*
c. Decision Making					
- company	H	L	M	M	H*
- investor	L	L	M	M	H
- regulator	H	L	M	M	H*
2. Economic					
a. Economic substance	H	L	M	M	H*
b. Economic efficienty	H	L	M	M	H*
3. Mathematical	L	L	M	M	H
4. Requiremnt for Estimates	L	L	M	M	H
5. Tracking usefulness	H	L	M	M	H*

L = Low
M = Medium
H = High
H* = High Importance and High Conformance

1. People ex rel. Brooklyn R. Co. v. State Tax Comm'rs, 69 Misc. 646, 127 N.Y. Supp. 825 in J.M. Bryant and R.R. Herrmann, Elements of Utility Rate Determination (New York McGraw - Hill, 1940), p. 115.

2. Ibid., p. 118

3. M.T. Farris and R.J. Sampson, Public Utilities: Regulation, Management, and Ownership (Boston: Houghton Mifflin, 1973), p. 110.

4. Ibid., pp. 110-111.

5. G.A. Welsch, C.T. Zlatovich, D.A. Wilson and M. Zin, Intermediate Accounting (Georgetown, Ontario: Irwin - Dorsey, 1976), p. 474.

6. P.J. Garfield and W.J. Lovejoy, Public Utility Economics (New Jersey: Prentice-Hall, 1964), p. 95.

7. O.L Luper and P. Rosenfield, "The APB Statement on Basic Concepts and Principles", J.R. Parker, ed., Accountancy: A Sourcebook of Readings (Toronto: Pitman, 1973), p. 5.

8. M. Gordon and G. Shillinglaw, Accounting, A Management Approach (Illinois: Irwin, 1969), p. 89.

9. G. Terborgh, Realistic Depreciation Policy, Machinery & Allied Products Institute (Chicago: Lakeside Press, R.R. Donnelly & Sons, 1954), p. 3.

10. J. M Bryant and R.R. Herrmann, Elements of Rate Regulation (New York: McGraw - Hill, 1940), p. 126.

11. H.C. Spurr, Guiding Principles of Public Service Regulation, Vol. III (New York: E.R. Andrews Printing Company, 1926), p. 2.

12. 1965 Depreciation Guide Including New Liberalized Rules (New York: Commerce Clearing House, Inc, 1965), p. 14.

13. J.D. Coughlan and W.K. Strand, Depreciation Accounting, Taxes and Business Decisions (New York: Ronald Press Company, 1969), p. 1.13.

14. E.L. Grant and P.T. Norton, Jr, Depreciation (New York: Ronald Press Company, 1965), p. 184.

15. C.W. Lambden, D.L. Gerboth and T.W. McRae, Accounting for Depreciable Assets (New York: American Institute of Certified Public Accountants, 1975), pp. 41-45.

16. Ibid., pp. 41-42.

17. Industrial Week, V. 169:32, May 10, 1971.

18. J.W. Bennett, "Accounting for Real Estate Development Operations - Another View", Canadian Chartered Accountant, V.100:29, April, 72.

19. G.A. Welsch, et al, p. 20.

20. F.W. Inman and C.E. Miller, Contemporary Physics (New York: MacMillan, 1975), p. 249.

21. G.A. Welsch, et al, pp. 477-78.

22 W.T. Baxter, Depreciation (London: Sweet & Maxwell, 1971), p. 103.

23. O. Johnson, "Two General Concepts of Depreciation", Journal of Accounting Research, V.6, No.1:36, Spring, 1968.

24. A.F. Friedman and R.D. White, "A Logical Method of Depreciating Buildings, Appraisal Journal, V.XLII, No.4:550, October, 1974.

25. J.C. Bonbright, Principles of Public Utility Rates (New York: Columbia University Press), p. 208.

26. A.F. Friedman and R.D. White, p. 564.

27. CICA Terminology for Accountants.

28. L.H. Malchman and A. Slavin, Foundations of Accounting for Managerial Control (Philadelphia: Chilton, 1959), p. 362.

29. O.R. Burt, "A Unified Theory of Depreciation", Journal of Accounting Research, V.10:29-57, Spring 1972.

30. C.L. Bullock, "Accounting Conventions and Economic Reality", Journal of Accounting Research, V.XLIV:22, July, 1974.

31. G.A. Welsh, et al, pp. 480-1.

32. O. Johnson, p. 29.

33. Ibid., p. 35.

34. W.J. Vatter, "Accounting For Leases", Journal of Accounting Research, V.4:148, Autumn 1966.

35. C.L. Bullock, p. 23.

34. Y. Goldschmidt, Information for Management Decisions, (Ithaca: Colonial Press, 1970), p. 72.

37. H. Bierman, Jr. and A.R. Drebin, Managerial Accounting, An Introduction (New York:MacMillan, 1968) p. 271.

38. A. Friedman and R.D. White, p. 550.

39. O. Johnson, p. 29.

40. S.H. Sosnick, "Depreciation: The Offsetting Interest Method", The Accounting Review, V.37:65, January 1962.

41. J.W. Bennett, p. 29.

42. I. Reynolds, "Selecting the Proper Depreciation Method", The Accounting Review, V.XXXVI, No.2:243-44, April, 1961.

43. B. Horwitz and A. Young, "Extra Ordinary Gains and Losses and Security Prices", Quarterly Review of Economics and Business, V.14:108, Winter, 1974.

44. W.J. Graham, Public Utility Valuation (Chicago: University of Chicago Press, 1934), pp. 53-54.

45. Ibid., p. 56.

46. Lambden, p. 44.

47. Re: Elizabethtown vs. Elizabethtown Water Co. (N.J) PUR 1927 E, 39.

48. E.O. Edwards, "Depreciation and the Maintenance of Real Capital", L.J. Miej, ed., Depreciation and Replacement Policy (Amsterdam: North-Holland Publishing, 1961), p. 62.

49. O. Johnson, p. 36.

50. W.T. Baxter, Depreciation (London: Sweet & Maxwell, 1971), p. 104.

51. K. Lancaster, Introduction to Microeconomics (Chicago: Rand-McNally, College Publishing Co, 1974) p. 319.

52. O. Johnson, p. 36.

53. I.M. Stelzer, "Pricing in Regulated Industries: A Not-So-Marginal Problem", J.E. Haring, ed., The New Economics of Regulated Industries: Rate Making in a Dynamic Economy (Los Angeles: Economic Reserarch Centre, Occidental College, 1968), p. 133.

54. W.T. Baxter, p. 103.

55. A. Friedman and R.O. White, p. 554.

CHAPTER THREE

REGULATION

3.0 GENERAL

To make a decision on what type of depreciation method would be best for regulating a utility, it is important to understand several aspects of regulation itself. Analyzing the characteristics of regulated companies might offer some insight into the objectives of regulation.

Several authors suggest that regulated industries are sufficiently "affected with public interest" that they need to be subjected to some controls. Because of their share of the total national output and their position as main constituents of the infrastructure of industry, their development has a large impact on general economic development. However, it is not sufficient that an industry be important to the economy to be a proper candidate for regulation, for if this were true, many non-regulated companies would have even more reason to be regulated than those that presently are.

Bonbright[1] suggests four reasons for regulation. The first of these, the "producer-motivation" or "capital-attraction" function, consists of creating an environment where an entrepreneur will enter and then stay as a supplier in a market which he would not necessarily have entered otherwise. This function requires the existence of an implicit agreement to serve customers on the

assumption that all costs will be reimbursed in full.

The next function, that of "efficiency-incentive", consists of creating an environment in which the most efficient combination of resources would be applied to fulfilling a certain need.

Klass[2] splits up Bonbright's efficiency function into two useful categories, input and output efficiency. The latter, which measures if the industry produces the output at a price which equals the marginal cost of production, is a topic of myriad articles on rate design.

The more evasive "input efficiency" deals with the level to which the industry optimally combines input resources to minimize costs for whatever level of output is produced. This involves the very complex area of productivity analysis which is outside the scope of this paper but deserves further study. This paper will limit itself to the output efficiency.

A third, "demand-control" or "consumer rationing" is an attempt to control prices in such a way as to perform the function of allocating scarce resources between consumers without imposing an overt rationing device, effectively making the consumer ration himself. This reason for regulating price reflects the concept of "customer sovereignty". Prices are designed to let the customer be the judge of his own needs or wants, subject to the requirement of compensatory payment.

The fourth function, denounced by Bonbright as an illegitimate aspect of regulation, but nonetheless practiced widely, is the "income distributive" function. This role of regulation consists of using utility rates to transfer wealth either from the consumer to the owner of the utility or to transfer wealth between consumers. Bonbright frankly discusses this function as follows:

> "Rates are not regarded as instruments for an attempted correction of personal income disparities, save in highly specialized cases, and then only as makeshift devices ..."3

Most regulatory jurisdictions now use some form of the "Rate Base Method" of rate regulation. This process is split into two phases, corresponding roughly to Bonbright's four objectives.

The first two of his objectives deal with the supplier, insuring the continuity of supply and efficiency of resource allocations through a monopoly while attempting to imitate the pricing advantages of perfect competition. This corresponds with Phase I of a normal rate hearing, the setting of revenue requirements and will be further explored under the heading of "Economic Efficiency".

The second two objectives correspond to the function of Phase II of the Rate Hearing, rate design. This will be covered under the heading of "Equitable Distribution of Costs." This section will show how the regulator negotiates the fairest distribution of wealth between the owner and various consumer classes.

Depreciation is intimately tied to both of these phases. After each phase is discussed, the role of a proper depreciation method will be expanded upon.

There are also some inherent practical problems associated with Regulation which could be aggravated if the wrong depreciation technique is applied. These problems will be covered after the two objectives have been discussed.

3.1 ECONOMIC EFFICIENCY

Certain characteristics of the types of service provided by a utility make a monopoly the most economical vehicle for fulfilling consumer demand. Unfortunately, along with these advantages come some inherent shortcomings in the form of potentially high and discriminatory rates. The first part of this section will outline how the regulator maximizes the economic advantages and minimizes the disadvantages. The second part will show how different depreciation techniques assist or hamper the regulator in this optimization.

3.1.1 Advantages and Disadvantages of a Monopoly

This section will show why utilities are "natural" monopolies, how unregulated pricing differs between a monopoly firm and firms under perfect competition and what the regulator does to make the most of these facts.

1) Existence of a Natural Monopoly

As Lancaster states, monopoly (from Greek routes meaning "single seller") can be preserved by:

> "1. Legal prohibitions on entry such as copyrights and franchises (direct prohibition of other firms), patents (which prevent other firms using some essential technique of production), trademark (which makes it difficult for other firms to convince buyers that their product is identical).
> 2. Economic Barriers to entry derived primarily from the existence of indivisibilities so that a competitor cannot start in a small way and build up, but must operate on a large scale from the beginning ... thus ... even if other firms enter, they will be few and large, leading to an oligopoly situation.
> 3. Informal and frequently illegal barriers such as physical and financial intimidation of potential competitors."[4]

While utilities may survive as monopolies by exercising the first and last types of barrier to entry, the dominant characteristic of a natural monopoly is the economic barrier to entry. There are several reasons why an established utility can find economic advantages over the new entrant. These are presented in three areas:

a) Increasing economies of scale.

b) Market power.

c) Engineering advantages.

a) Increasing Economies of Scale

Many investments in the utility field enjoy increasing economies of scale over a large range of production, making the incremental cost of serving new customers less than the average price. The established firm can therefore, generally offer new service at a lower price than a new entrant to the market. There are several reasons for these economies of scale:

i) Common Costs

The first of these is the existence of many common costs. Once a cost has been incurred, it does not need to be re-incurred as the level of production increases. For example, the Accounting department need not double if company production doubles.

ii) Lumpy Investments

Because of the design of utility equipment, it is often hard to purchase small quantities of production devices. For example, it would not be possible to add telephone lines to a central office line by line or buy electrical generating capacity kilowatt hour by kilowatt hour. Capacity comes in lumpy increments.

iii) Network Configuration

In most utilities, economies are gained by connecting the various customers in a network configuration. This

savings is only realized by optimizing the entire system over all customers and over some time period. If twice the number of people were connected, costs might be significantly less than doubled.

iv) Fungible Plant

Most utility plant is reuseable or "fungible" by different customers. If a piece of equipment does go out of service at one location, it can often be reused elsewhere. This flexibility can only be realized by the initial expenditure of capital dollars. Once the dollars are spent, the plant can be rearranged with minimal transaction costs.

v) Critical Mass of Investment

Because of the gargantuan sums of money required to finance a viably large utility, very few firms can generate enough capital to get "up to speed" with an established supplier.

b) Market Power

Besides economic barriers to entry, utilities enjoy certain marketing advantages.

i) Speculative Supply

Since it is often only marginally more expensive to put excessive capacity in at the same time as that required

for existing demand, a monopoly firm may speculatively supply potential service for future customers. This allows the firm to respond more quickly to customer demands than could a smaller supplier.

ii) End-to-End Service Capability

In this age of convenience, many people prefer a "one-stop shopping" approach to their buying activities. A utility which can promise end to end service may have a distinct advantage over a number of disjointed suppliers. In the telecommunications industry, this is especially true because of the monolithic nature of the service. There is an inherent value in the universal connectability, which does not occur in other utilities.

c) Engineering Advantages

If a single firm can gain control of the industry, it can save even more money if it can control technological pollution by standardizing on a minimum number of customer options. If it has control over market growth, it can also save money by optimally placing plant over time. This will be explained further in Chapter Four.

So it is apparent there are several reasons why a utility company can enjoy a natural monopoly.

2) Monopoly versus Perfect Competition

It seems clear that the cost of providing service, at least in certain parts of the utility field, would be minimized if the customer was served by a monopoly, a single firm, and that over the long run the single firm would survive the threats of companies which try to compete with it. It would cost money, useless to society, to have imperceptive entrepreneurs venture into the fray with an established monopoly only to find out all the others were right, they could not compete. There are other, more fundamental reasons for regulation though, than protecting society from over-zealous but under nourished small companies.

It is generally conceded that a monopoly will tend to produce goods at a lower cost. However, the monopoly will not necessarily pass these cost savings on to the customer voluntarily. In fact, as Lancaster demonstrates,

> "if there are no indivisibilites, leading to economies of scale, the comparison is direct and simple. The long run average cost will be the same for the competitive industry and the monopoly, and the marginal cost will coincide with average costs. Demand conditions are assumed to be unchanged by the structure of the industry."[5] The comparison is given in Figure 3.1.

For perfect competition, the market equilibrium will be at C, the intersection of the supply and demand curves, giving Competitive output Qc and competitive price, Pc.

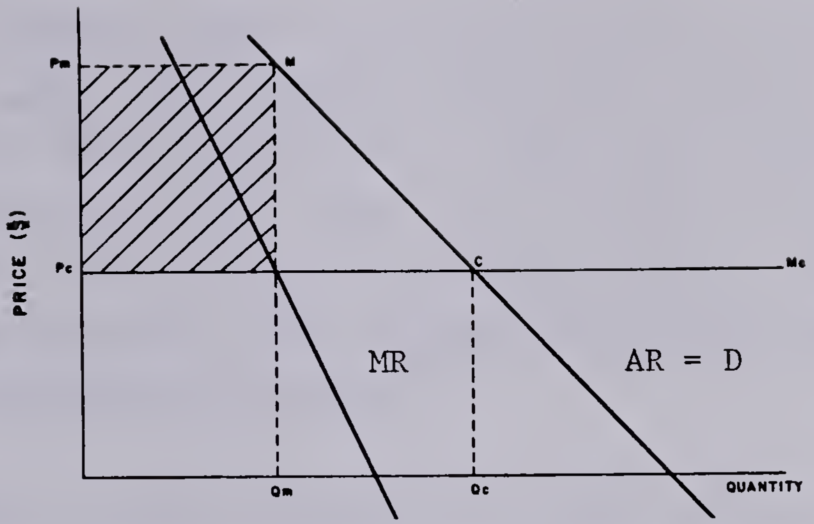


Figure 3.1

Comparison of Price and Quantity of
Monopoly and Perfect Competition

For a monopoly, however, the point supply of the firm will be set at the point M, giving monopoly input Qm and monopoly price Pm. Direct comparison gives the simple rule:

> "A monopoly will produce a smaller output and sell at a higher price than the equivalent competitive industry."

The difference between Pm and Pp can be thought of as <u>monopoly markup</u> ... the shaded area in the figure is excess profit over and above the profit that would be made by the competitive industry. It is usually referred to as the <u>monopoly profit</u>.[6]

Kiezer continues on with this analysis saying,

> "This is the efficient level of production because price equals marginal cost. The price the consumer pays for the product, which is a measure of the satisfaction that he derives from the last unit of it, is equal to the cost of producing the last unit. Satisfaction is then equal to sacrifice or cost, the

> other products given up to use resources to produce this good. Under imperfect competition prices are greater than marginal cost. This means that the satisfaction derived from the last unit is much greater than the cost of producing the last unit. By producing more, total consumer satisfaction could be significantly increased."[7]

This effect is more pronounced in most utility fields since their goods are typically essential commodities, thereby indicating highly inelastic demand functions. Samuelson makes some additional comments on the macro scale:

> "Only when prices of goods are equal to marginal cost is the economy squeezing from its scarce resources and limited technical knowledge the maximum of outputs. Only when each source of industry output has had its rising MC equated to any other sources MC - as will be the case when each MC has been set equal to the common P - can the industry be producing its total Q at minimum total cost. Only then will society be out on its production - possibility frontier and not inefficiently inside that frontier."[8]

3) Objective of Regulation in a Natural Monopoly

In summary, the economic reason for regulation is to accrue the cost efficiency of a natural monopoly while achieving the pricing efficiency of perfect competition. As the Louisiana Supreme Court stated,

> "Because public utilities enjoy monopoly status and are not subject to the competitive forces of the

market place, public regulation of their affairs must act as a substitute to prevent a utility from dealing unfairly with its customers."[9]

Since the price a firm would charge if it were in perfect competition remains a hypothetical amount, regulators have to rely on a "Fair Return" on investment as the surrogate for true perfectly competitive pricing. This brings us to the role of depreciation in fulfilling the economic efficiency objective of regulation.

3.1.2 Role of Depreciation in Phase 1 of Regulation

While both Phases of rate making use depreciation calculations extensively, phase 1, setting revenue requirements, is the more significant of the two since it actually sets the amount of money the utility is to earn.

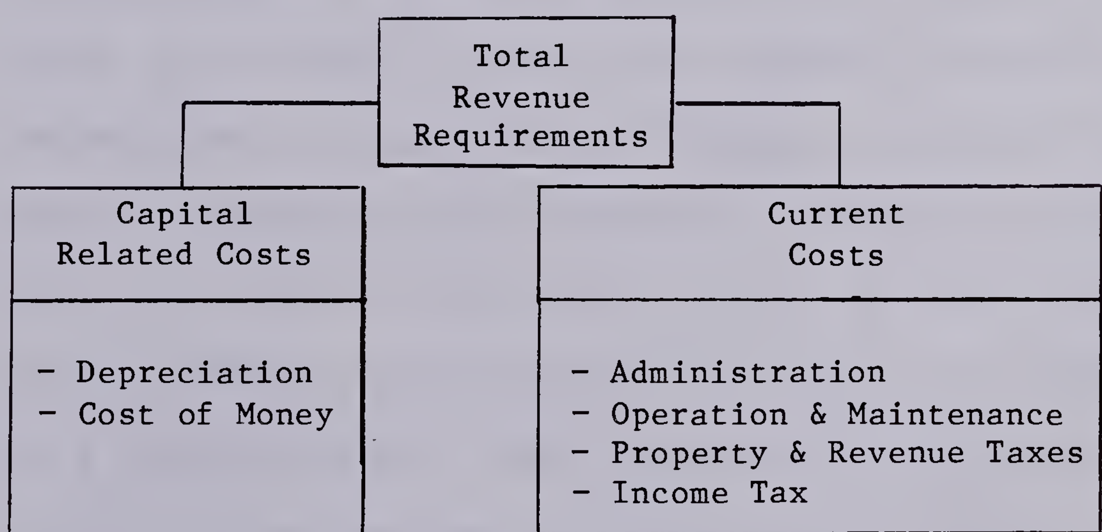


Figure 3.1

Schematic Representation of Revenue Requirements

The revenue requirement, the total revenue required for the utility to remain viable, can be split up into two major components; that

required to cover capital related costs and that which covers current or operational costs (see figure 3.2).

1) Capital Related Costs

Capital items are those significant items which are purchased during a particular year, but whose useful life spans a period greater than one year. Capital items generate two types of costs, one an accrual of the assets value, a non-cash item, the systematic repayment of the costs of the asset itself. The other, a cash flow item, is the cost of money or interest. The cost of money can be an actual payment of interest on debt or the actual or implicit payment of dividends on equity.

a) Capital Repayment

Calculating the allowable repayment of the cost of the asset to the firm is the most observable function of depreciation. A depreciation technique, to fulfill this aspect of regulation, must perform the "Capital-attractive" function; it must be such that it assures the owner that he will eventually receive back all the money he has invested in a particular asset. Since the owner always has only the actual deteriorating asset to theoretically dispose of, he should feel he has collected at least enough money through depreciation so the amount he has "at risk", or unrecovered, is no more than the remaining economic value of the asset itself.

Unfortunately, another function is often held out for the depreciation expense, namely, the regeneration of funds for financing plant replacement and plant extensions. This function, while it has preoccupied regulatory writers for decades, is, at least in part, illusory. First, looking back on the history of any particular utility, there had to be a first asset which was financed entirely by external and equity funding. The motivation for the investors in that instance was a good compromise between risk and return. While it is important to inspire investors' confidence, the sole reliance on a hefty accelerated depreciation expense for this job is myopic and unhealthy.

Second, in times of inflation, except if the regulator is inclined towards price level accounting, the depreciation expense generated on old assets will likely be hopelessly inadequate for financing the more costly new replacement. As some studies indicate, depreciation accounts for a very small proportion of the actual replacement costs.

> "For example, a recent report on a large mid-western utility shows that the historical depreciation for all of its facilities in 1974 was 111 million dollars but on a constant value basis, the reproduction value for these facilities was 459 million dollars in 1974."[10]

b) Interest

Besides the direct effect of depreciation on capital assets, depreciation also effects the interest component.

Table 3.1

Comparative Ratios of Accumulated Depreciation to Total Plant for Major Canadian Telephone Companies (1978)

Company	Plant at Cost ($000)	Accumulated Depreciation ($000)	Percentage
A.G.T.	1,678,979	420,808	25.1
Bell Canada	8,685,264	2,496,256	28.7
B.C. Tel.	2,115,788	473,982	22.4
'edmonton tel.'	321,126	85,282	26.6
Manitoba Tel.	618,977	186,064	30.1
Maritime Tel. & Tel.	494,227	126,793	25.7
New Brunswick Tel.	411,470	118,358	28.8
Newfoundland Tel.	234,345	63,348	27.0
Northern Tel.	43,117	13,807	32.0
Quebec Tel.	335,539	83,826	25.0
Saskatchewan Tel.	640,456	168,315	26.3
Island Tel.	57,232	11,199	19.6
Telebec Ltd.	146,225	40,932	28.0
Total	15,782,745	4,288,970	27.2

Source: Government of Canada, Department of Communications, 1978, Financial Statistics on Canadian Telecommunications Common Carriers, p. 16-17.

Most regulatory agencies use some form of "return on rate base" to calculate and verify estimates of allowable return. Although not vigorously practiced by regulators, this return may be adjusted to reward or punish relative

"input efficiency" or to enhance the "capital-acquisition" function. The rate base includes all "prudently" acquired assets plus allowance for working capital and plant acquired at other than historical cost. From this aggregate, the total depreciation which has accumulated over the years on all remaining assets is subtracted. This accumulated depreciation is a large proportion of total capital. (See Table 3.1)

If the amounts of depreciation collected in all preceeding years is different using one method versus another, the effect on the return component is the aggregate of all these differences, not just the difference from one year. Therefore, at certain times of a utility's asset cycle, the effects of depreciation induced differences in interest may be greater than any one yearly difference in depreciation expense itself.

2) Current Costs

Current costs refer to any costs whose benefit is expected to last less than one year. For example, fuel to power an electrical generating station is purchased and consumed within one year, and the power so created can only be used to generate revenues during that year. These costs are usually categorized into operations, maintenance, and administration costs. Many utilities also have to pay property, revenue or franchise taxes, which are also "allowable expenses". Privately owned utilities

would pay income tax on any return on equity. Publicly-owned utilities would normally be exempted from income tax.

Table 3.2

Total Revenue Requirements and Depreciation Expense
Canadian Telephone Companies (1978)

Company	Total Revenue Requirement ($000)	Depreciation Expense ($000)	Percentage
A.G.T.	440,584	125,068	.369
Bell Canada	2,255,635	473,989	.266
B.C. Tel.	508,554	112,619	.286
'edmonton tel.'	75,847	15,796	.273
Manitoba Tel.	147,668	33,674	.297
Maritime Tel. & Tel.	131,319	27,870	.280
New Brunswick Tel.	109,377	21,798	.261
Newfoundland Tel.	60,385	13,138	.296
Northern Tel.	12,997	2,192	.226
Quebec Tel.	76,415	18,514	.326
Saskatchewan Tel.	148,275	33,895	.289
Island Tel.	14,324	2,971	.282
Telebec Ltd.	37,335	7,790	.271
Total	4,018,715	889,315	.283

Source: Department of Communications, p. 52-53.

All allowable current expenses are added to capital related costs to get total revenue requirements. Depreciation expense makes up a very large percentage of the total revenue requirement (see Table 3.2)

The current trend is to determine the revenue requirement by an extrapolation of retrospective analysis into a "future test year(s)". The rate base method, as described above, (See Figure

3.3) is very sensitive, both yearly, and especially cumulatively, to the choice of depreciation methods.

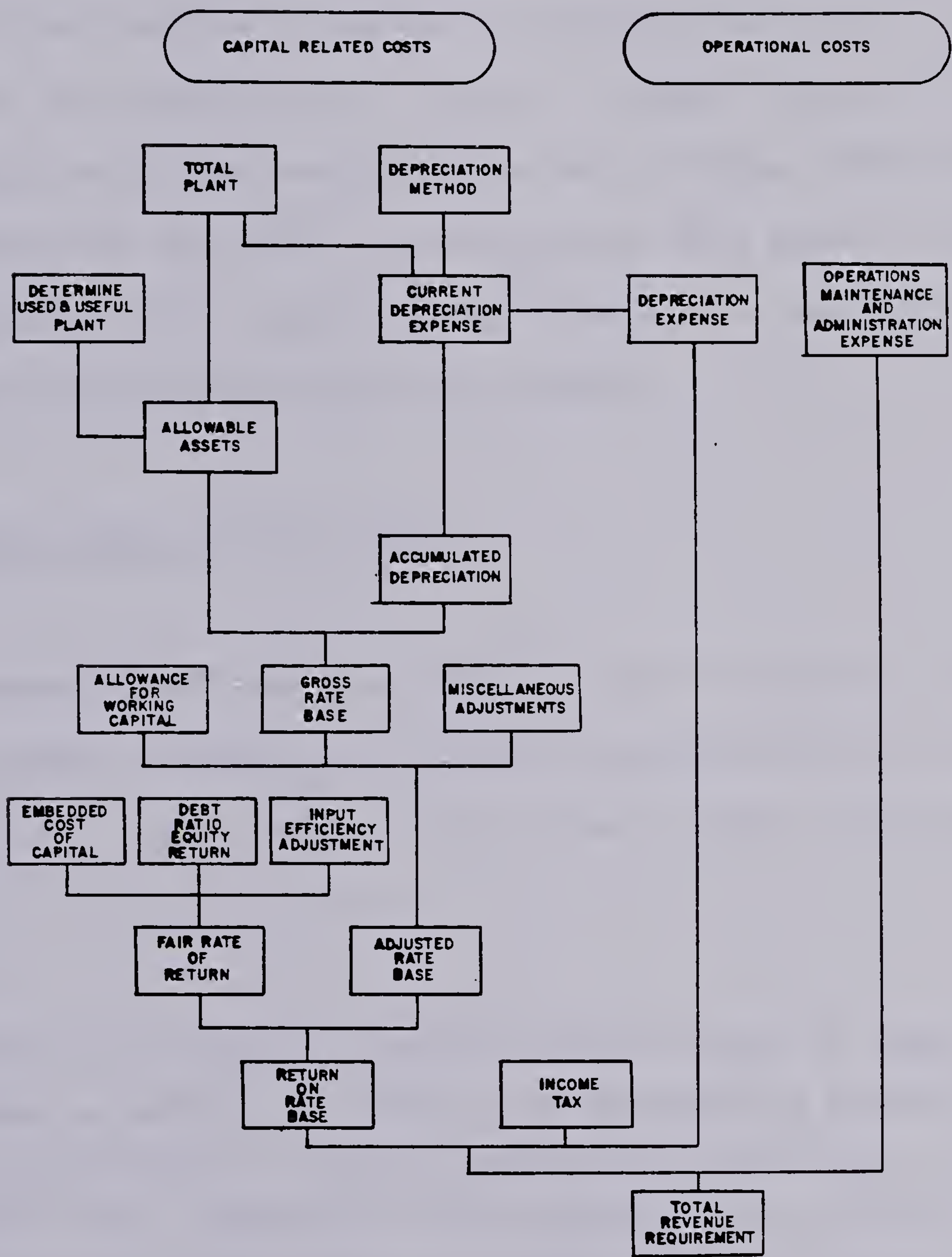


Figure 3.3

Schematic Representation of Rate Base Method - Phase I

3.2 EQUITABLE DISTRIBUTION OF COSTS

After the revenue requirement has been established, the Regulator

also wants to insure that the individual rates are fair. To this end, the rate case proceeds to Phase II, Rate Design. The Rate Design phase is used to determine which services will absorb what part of any required increases in revenue requirements. Several schools of thought exist over the "proper" rate to charge. Economists will offer suggestions on how to design "efficient" rate structures but they defer any decision on their moral or normative attributes to the courts, saying there is no true way to pass judgement on the properness of any method.

3.2.1 Regulatory Basis for Rate Design

The regulator need not muse over the actual purpose of Phase II, rate design, because most regulatory legislations make the point very clear. For example, in the Alberta Public Utilities Board Act:

> "87.(1) No owner of a public utility shall; a) make, impose or extract any unjust or unreasonable or unjustly discriminatory or unduly preferential individual or joint rate, computation rate, mileage or other special rate, toll, fare, charge or schedule for any product or service supplied or rendered by it within Alberta".[11]

In the Prince Rupert Gas case, this was further clarified by Mr. Justice Davy of the Court of Appeal of British Columbia as he described the legal character of "subsidization". He states,

> "... that contribution to the overall costs becomes a subsidy if its specific purpose is to benefit other

consumers without regard to the extent those costs properly enter into the cost of serving the contributing consumers".[12]

Bonbright[13] suggests three levels of fairness:

1. Good Faith Standards

The standards suggest that there exists an implied contract between consumer and producer, a moral obligation based on the reasonable expectation that the utility continue to provide service on the basis of past rates and that the utility will continue to be paid properly for committed resources.

2. Income Distributive Standards

This standard contains two rival positions, one which says that fair payment is where cost equals price (indemnity or close) and one which says that fair payment should reflect ability to pay.

3. Notional equality standards

This standard recommends uniformity of rates in spite of differences in costs or demand elasticity.

Bonbright's recommendation for the best standard is revealed later in his book.

"The previous chapter has taken the position, held in

> common with other economists that the compensation principle of rate making is far preferable to an ability to pay principle, save under certain emergency conditions.[14]

This standard of fairness based on costs need not extend only to the consumers in a single year, but as Graham suggests, also over time and as he elaborates:

> "Since these uniform price level changes really reflect actual changes in the value of the monetary unit, it would seem reasonable and equitable to adjust, in so far as possible, the costs to the consumer and the return to the investor until they are uniform in purchasing power rather than in terms of money".[15]

3.2.2 Impact of Depreciation on Rate Design, Phase II

The state-of-the-art process of rate design consists of three stages. First, all assets and costs are allocated to functional cost categories, with each category comprising a roughly homogenous collection of costs that vary fairly linearly with some sub-unit of service. These sub-units of service, sometimes called "planning units", can be used in various mixes by different customer classes. By determining the numeric amount of units used, by customer class and in total, these functional cost categories can be allocated proportionately to each class. Rates are then established for each customer class which, in total, will give the same allocation to that class of customers as is suggested by the functional cost analysis.

One such component of this functional cost calculation is depreciation expense. Different customer classes have different relative uses of plant. If one group uses a predominance of assets which are particularly badly biased by the choice of depreciation method, their rate would tend to be biased in that same direction. Therefore, the choice of depreciation method is a very sensitive component of rate design, just as it is to the calculation of revenue requirements. For example, if the commercial class of customer uses more of a particular asset than the residential customer and this asset typically fills up slowly over a long life span, the anomalies of using straight line instead of fill adjusted depreciation would cause the rates to the commercial class of customers to be relatively higher than to the domestic class of customers.

3.3 PRACTICAL PROBLEMS OF REGULATION

The objectives of regulation, to ensure that consumers obtain utility services at the lowest and most equitable price possible, are noble indeed. However, there are several shortcomings of the existing regulatory procedure which may impact on the choice of alternative depreciation methods. These limitations will be presented in five areas.

1. The dilemma of the sanction versus solvency.
2. Regulatory lag.
3. Motivational aspects.
4. Costs of regulation.

5. Positive aspects of short comings.

3.3.1 Sanction Versus Solvency

As Bussing suggests,

> "Public Utility Regulation in the last analysis, is Price Regulation, limited by the fundamental requirement that a company's solvency must be maintained".[16]

While the range of pricing which will allow a utility to provide service and inspire investor confidence for future growth is wide, a minimum level of rates must be retained or else the investor has no incentive to continue to supply service.

The formidable task of deciding to lower a utility's rate of return really consists of two decisions. First, the regulator must somehow evaluate the degree of efficiency with which the utility is providing the prescribed level of service. If this is less than prudently attainable, the regulator must then undertake to determine if it would be more efficient to have the utility collapse financially and be taken over by an untried replacement or just to cover up the company's extravagances in quiet discontent. All too often, the second course of action is pursued.

The more complexity required to evaluate a firm's performance, the more reluctant will regulators be to evaluate it. A depreciation technique which adds "noise" to the financial data makes this evaluation even more difficult.

3.3.2 Regulatory Lag

As rate hearings become larger and more complex, the time between applications for a rate increase and the actual order for rate hike may be very extensive. In many utilities, one rate hearing is barely over, and perhaps still going on, when the next one is required. If a technique for setting rates is not long term in its approach, this problem is compounded by a frequent requirement to return to face the Board for more money. Specifically, if the depreciation technique causes violently fluctuating rates, the frequency of rate cases and the effect of regulatory lag will be increased.

3.3.3 Motivational Aspects

In a previous section, one reason for regulation was given as a requirement to ensure efficient utilization of resources through proper pricing. Since rates are granted in direct relationship to the rate base, it would seem likely to assume that utilities would be motivated to indulge in the sport of so called, "rate base building". This phenomenon, as speculated by Aversch and Johnson[17] suggests that current regulatory practices would motivate utilities to add plant imprudently. Aversch and Johnson go further to theoretically show that profit maximization, the supposed goal of any business entity, would be fulfilled by continuing to add "non-monopoly" services at a loss and collect cross subsidies from the monopoly service. Several authors besides Aversch and Johnson,

including Klass[18] and Wellisz[19] have dealt in depth with the effect of regulation on input efficiency. While regulations should attempt to optimize input efficiency, present rate making practices may, in fact, result in a motivation to be inefficient.

Another phenomenon called the "ratchet effect" relates to the practice of regulatory bodies to grant increases but not to insist on decreases when costs go down. The rate case is typically started by the utility when it is losing money. It is left to its own designs when it is not losing money. There is generally no systematic review procedure in place in most regulatory jurisdictions between rate cases. This, coupled with the rate base approach to rate making, suggests that utility owners will acquire useless or extravagant equipment during years of surplus, and go for a rate increase in years of deficit. The straight-line depreciation technique causes first, rates that are too high and then rates that are too low.

Any depreciation technique which allows the utility to find itself in a position to increase its profitability without raising rates will amplify the effects of this phenomenon. Regulatory lag will allow these limitations to carry on longer than they should, perhaps to the point where it becomes impossible to sanction the utility without threatening its solvency.

3.3.4 Costs of Regulation

By its nature, regulation is complex and costly. A typical rate

case involves the retention of several highly paid witnesses and legal council for the firm, the interveners and the Board. The utility testimony, evidence and cross examination often comprise several thousands of pages. The costs of all this are ultimately born by the consumer since costs are often awarded to the utility. For example, in Alberta,

> "60.(1) The costs incidental to any proceeding before the Board, except as otherwise provided in this Act, are in the discretion of the Board, and may be fixed in any case at a sum certain or may be taxed. (2) The Board may order by whom and to whom any costs are to be paid and by whom the same are to be taxed and allowed".[20]

3.3.5 Positive Aspects of Poor Regulatory Practice

In any event, the inadequacy of present regulatory practices is not one created by design but rather but lack of design.

Bonbright suggests that it may actually be the imperfections of the system which make it perform the efficiency-incentive function more adequately.

> "Private companies receive no guarantee of their ability to enjoy "fair rate of return", with the result that they may be under more or less severe pressure to practice operating economies and to stimulate growth of demand for service in order to earn the officially sanctioned rate (the significance of this no guarantee situation is enhanced by the general refusal of Commissions and Courts to recognize past deficiences or past excesses in corporate earnings as grounds for

> offsetting allowances in later rate cases)...
>
> There is the so called 'regulatory lag', - the quite usual delay between the time when reported rates of profit are above or below standard when an offsetting rate decrease or rate increase may be put into effect by Commission order or otherwise".[21]

Bailey[22] applies this concept in a more rigorous method to show that regulatory lag may mitigate the Aversch-Johnson effect under constrained return on capital.

SUMMARY

This chapter showed that the purpose of regulation is to negotiate the goals of the consumer, the utility and the state. This negotiation insures that the utility remains solvent, the consumer gets the most for his dollar and that each member of the state is treated equally fair.

Utilities generally enjoy a situation of "natural" monopoly which is inherently cost efficient. Regulation preserves this efficiency while mitigating the inherent unfair pricing practices of monopolies.

It does this through the process of the Rate Hearing which is conducted in two phases, 1) calculation of revenue requirement calculations and 2) rate design. The type of depreciation method used has a great bearing on the actual rates charged to customers in both phases.

Finally, regulation has many inherent shortcomings. It is important that the depreciation technique used should not amplify the shortcomings.

1. J.C. Bonbright, Principles of Public Utility Rates, (New York: Columbia University Press, 1961), p. 49.

2. M.W. Klass, & W.G. Sheppard, Regulation and Entry (Michigan: MSU Public Utility Papers, 1976), pp. 1-33.

3. J.C. Bonbright, p. 61

4. K. Lancaster, Introduction to Micro Economics, 2d ed,; (Chicago: Rand-McNally, College Pub. Co., 1974), p. 319.

5. Ibid, pp. 196-7.
6. Ibid, p. 197.

7. N.F. Kiezer, Economics: Analysis and Policy, (New York: John Wiley & Sons, 1965), p. 461.

8. P.A. Samuelson, Economics, 10th ed.; (New York: McGraw - Hill, 1973), p. 462

9. Louisiana Supreme Court, 9 P.U.R. 4th 354, 1927

10. Engineering News Record, V.194, No.12:63, March 20, 1975.

11. Public Utilities Board Act, Chapter 302 of the Revised Statutes of Alberta, Sec. 87.01 para. A.

12. Prince Rupert Gas Company Ltd. et al, the Inland Gas Company Ltd. (2) (1958) 25 WWR (N.S.), p. 368-370.

13. J.C. Bonbright, p. 126.
14. J.C. Bonbright, p. 130.

15. W.J. Graham, Public Utility Valuation, (Chicago: University of Chicago Press, 1934), p.55

16. I. Bussing, Public Utility Regulation and the So-Called Sliding Scale, (New York: AMS Press, 1968), p. II.

17. H. Aversch and L.L. Johnson, "Behavior of the Firm Under Regulatory Constraint", American Economic Review, V.52: 1053-69, December 1962.

18. M.W. Klass and W.G. Sheppard, p. 9.

19. S.H. Wellisz, "Regulation of Natural Gas Pipeline Companies: An Economic Analysis." Journal of Political Economy, V.2:3-21, Spring, 1971.

20. The Public Utilities Board Act, Sec.60.1.

21. J.C. Bonbright, p. 53.

22. E. Bailey, and R. Coleman, "The Effect of Lag Regulation in an A-J Model" Bell Journal of Economics and Management Science, Vol. 2 No 1: 278-292, Spring 1971.

CHAPTER FOUR
THE THEORETICAL MODEL

4.0 GENERAL

The preceeding chapters present a background to depreciation and regulation and suggest some normative measures of correctness for the "best" depreciation method.

This section will prepare the way for the next chapter where a program will be introduced to evaluate the impact of one depreciation method versus another on a real utility company. Since there is such a multitude of factors, each having an influence in a different direction, it is important to isolate the effects of each before running the data in aggregate form.

Throughout this chapter, because of the multitude of uses of the word "rate" (interest rate, depreciation rate, growth rate, rates for service), when it refers to the amount charged to the customer, the less accurate word "price" will be substituted.

A computer program has been developed to test a variety of parameters, each of which affects the discrepancy between techniques (see Appendix A). In total, six different parameters will be presented; first, three fundamental factors, all presented for a single asset:

1) interest rate,
2) service life of the asset, and

3) fill profile.

Then, to make the model progressively more applicable to real life situations, three practical factors are added:

4) growth rate of assets,

5) mortality curves of mass assets, and

6) inflation rate.

For each variable, a typical range is presented and a single value is chosen to go on to the next variable. For all six parameters, three measures of discrepancy were evaluated for both the Straight Line Method and FASFM. For changes in interest rate, all three measures are presented. For subsequent parameters, only the most appropriate measures are presented.

1) Net income (and rate of return))

The first measure used is net income. For all the theoretical models presented, it is assumed that capitalization is totally funded by debt. In that case, net income can be defined for the model as total revenue minus depreciation and interest.

The computer model can be programmed to pick an annual price which sets net income equal to zero in each year (ie. sets rates to just recover "revenue requirements") for either method. Because depreciation is different for either method, the prices will also be different.

Now suppose a person were to use the Straight Line Method to calculate prices (and therefore total revenues) and FASFM to set depreciation expense. Then the "apparent net income" thus obtained would give a practical measure of the discrepancy between the two methods. If the apparent net income were less than zero, a theoretical regulator would feel pressure to raise prices; if it were greater than zero, he would want to lower prices. The discrepancy shows the "apparent" rather than the real need to change prices.

Since the dollar values of assets are chosen strictly for illustration, it would not be fair to compare the discrepancy in net income caused by the six different parameters unless all used identical base data. To overcome this problem, apparent net income is also expressed as a percentage of outstanding capitalization, or "apparent rate of return". This rate of return can be compared to the target internal rate of return set over the project's life, to see the discrepancy between depreciation methods in relative rather than absolute terms.

In Chapter 2, it was shown that the Straight Line Method resulted in a non-uniform rate of return if prices over an asset's life were constant. The difference between internal and apparent rate of return is another measure of the amount of improper pressure placed on regulators by utilities to have rates adjusted when, in fact, they need not be, or vice versa.

2) Actual price (and normalized price)

The actual price charged for service under either method is perhaps the most relevant measure of discrepancy, since, in a regulated environment, it is the effect on price which finally should decide which depreciation technique is most proper. By calculating a price to give equal accounting rate of return when using the Straight Line Method, and comparing the amount of distortion between it and FASFM rates over time, it is easy to see graphically how one period of customer arbitrarily subsidizes another. Since the base (FASFM) price may change with changes in any of the variables, the price will also be shown in normalized dollars (i.e. actual price divided by FASFM price) to isolate intertemporal discontinuities.

3) Depreciation Expense (and Cumulative expense)

The final measure of discrepancy, depreciation expense, is of secondary importance only, since rate of return and actual prices are the real outputs used by regulators, whereas depreciation is only an input to prices. However, since regulators tend to focus on costs, with depreciation being a major cost component, it is presented as a significant measure. Cumulative depreciation is also presented for clarity in some cases.

4.1 INTEREST RATE

Because of the longevity of assets, interest rates could vary considerably across the life of an asset. In periods of low inflation rates, interest rates between 3-5% were common, whereas in today's economic climate, 12 - 16% may not be unheard of. Interest rates affect the depreciation expense pattern when using FASFM but leave it unaffected in the Straight Line Method. As can be seen below, as the interest rate increases, the discrepancy between the two test methods also increases for all measures.

1) Apparent Net Income and Accounting Rate of Return

As the interest rate rises, the apparent net income and the corresponding apparent rate of return (see Figures 4.1.1 (a) and (b)) using the Straight Line Depreciation and FASFM constant prices, look more negative in earlier years and more exorbitant in future years.

The amount by which the "Apparent Net Income" is less than zero is a major determinant of the vigor with which an owner would petition the regulator for a rate increase. This apparent short fall is actually a result of prices which will adequately cover costs, including return on investments, over the lifetime of the asset.

Just as significant, in the later life of the asset, it will appear to earn an exorbitant net income at proper prices. There would be pressure from the regulator, disregarding the "ratchet

effect" discussed in Chapter Three, to lower rates needlessly.

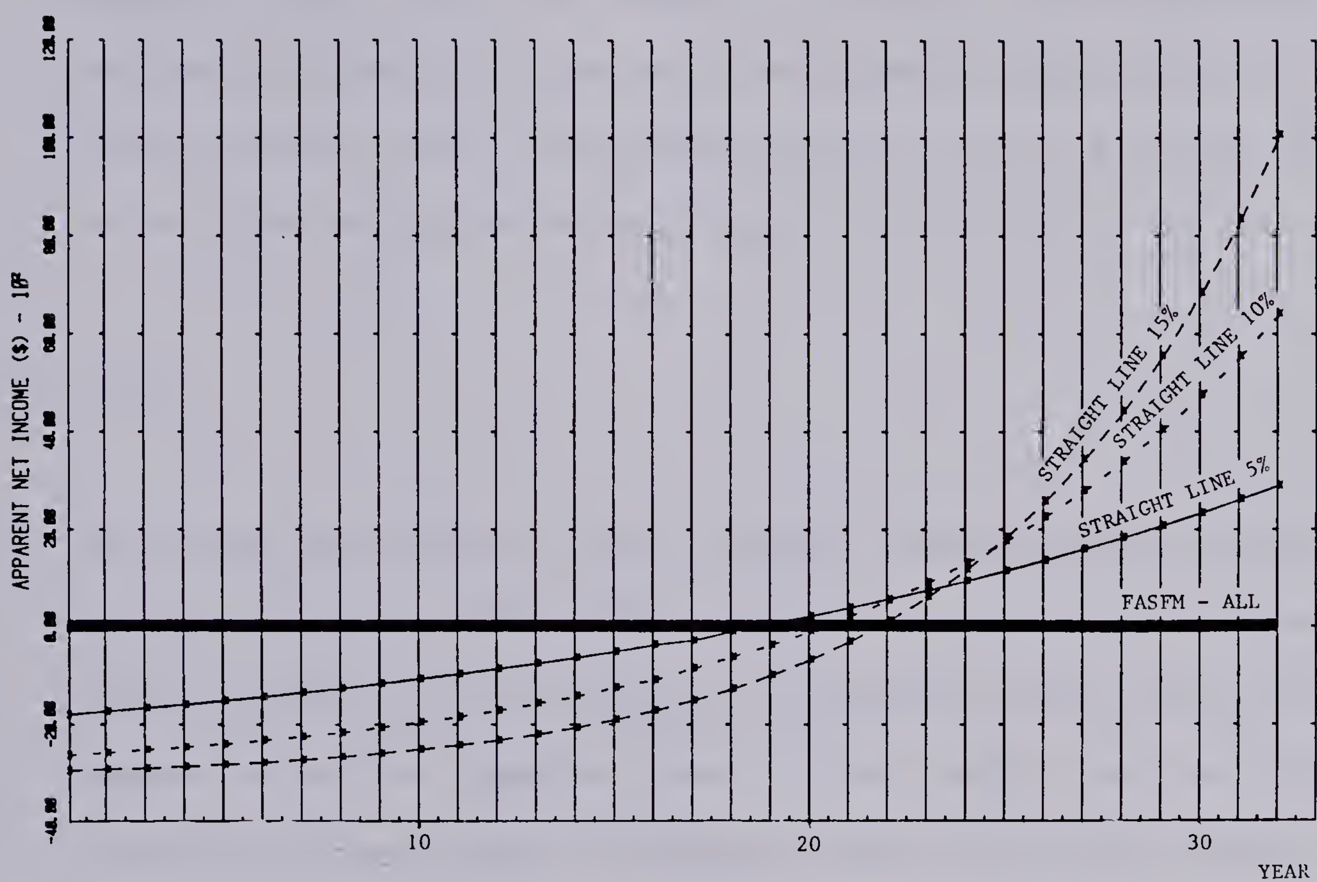


Figure 4.1.1 (a)

Comparison of Apparent Net Income
For Various Interest Rates

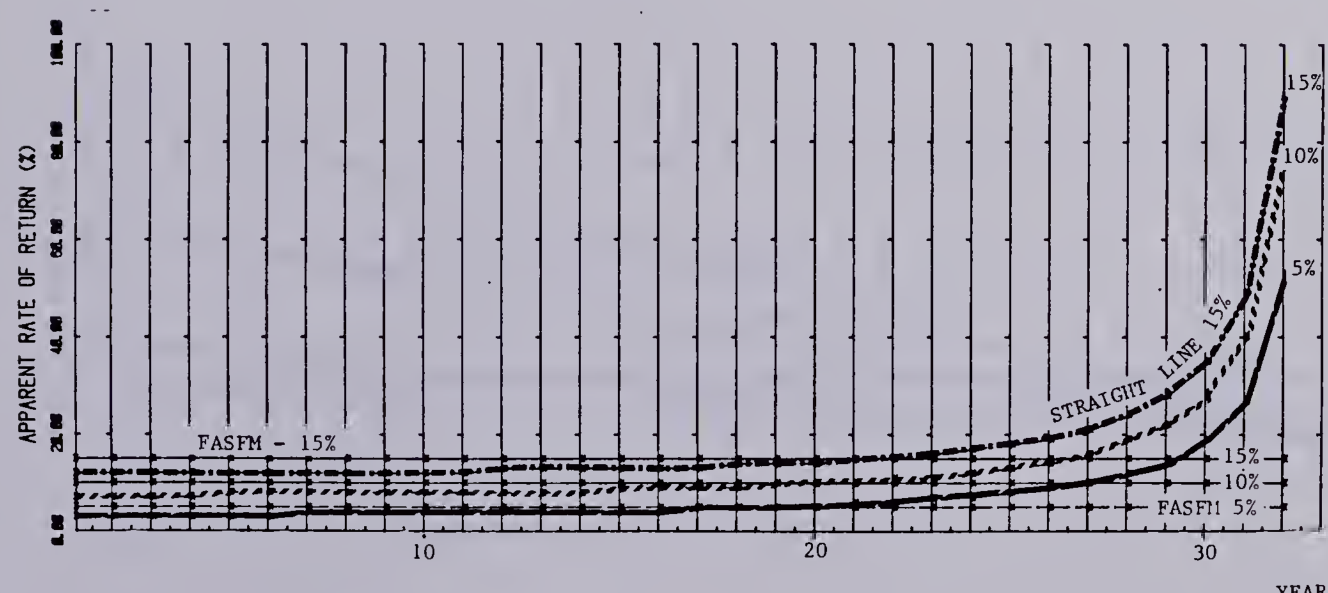


Figure 4.1.1 (b)

Comparison of Apparent Rate of Return
For Various Interest Rates

The Accounting Rate of Return undergoes an even more abrupt change. While the Net Income is rising, the outstanding undepreciated value of the asset is actually approaching zero. During the final year, the apparent rate of return rises to 91% for an asset earning an actual Internal Rate of Return of 15%.

2) Price

The higher the interest rate, the more heavily future periods revenues are discounted. This has the effect of raising prices in all periods. It is important to note that while the price changes with the interest rate in the FASFM case for any particular interest rate, it remains constant over time, whereas in the case of the Straight Line Method, the price fluctuates more as the interest rate increases (see Figures 4.1.2 (a) and (b)).

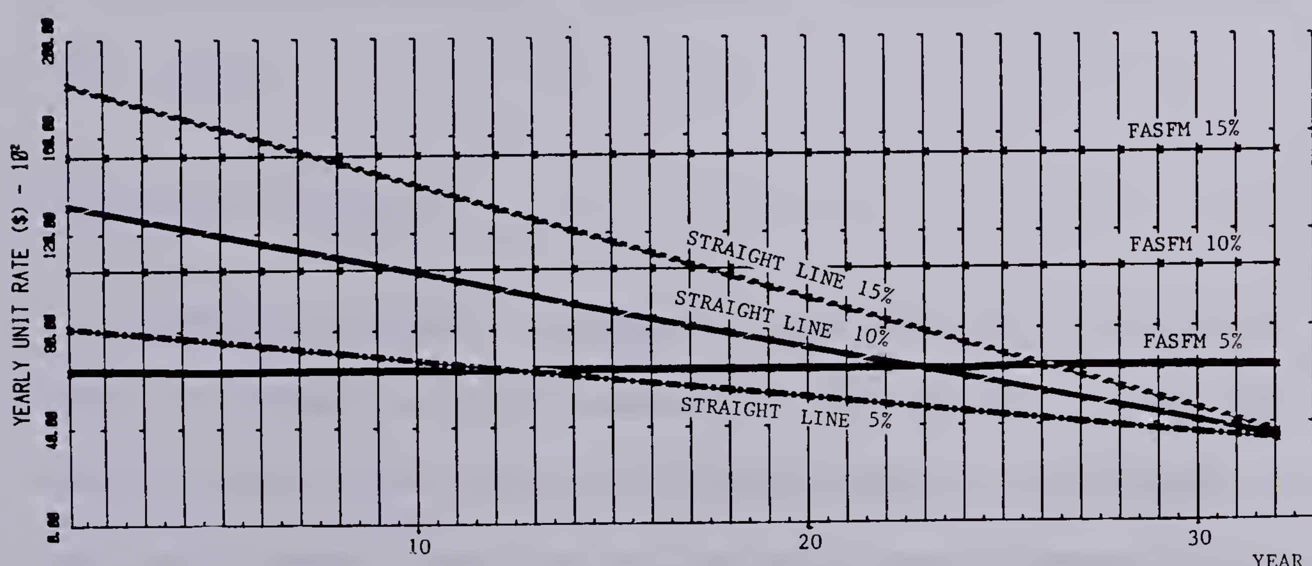


Figure 4.1.2 (a)

Comparative Prices for Various Interest Rates

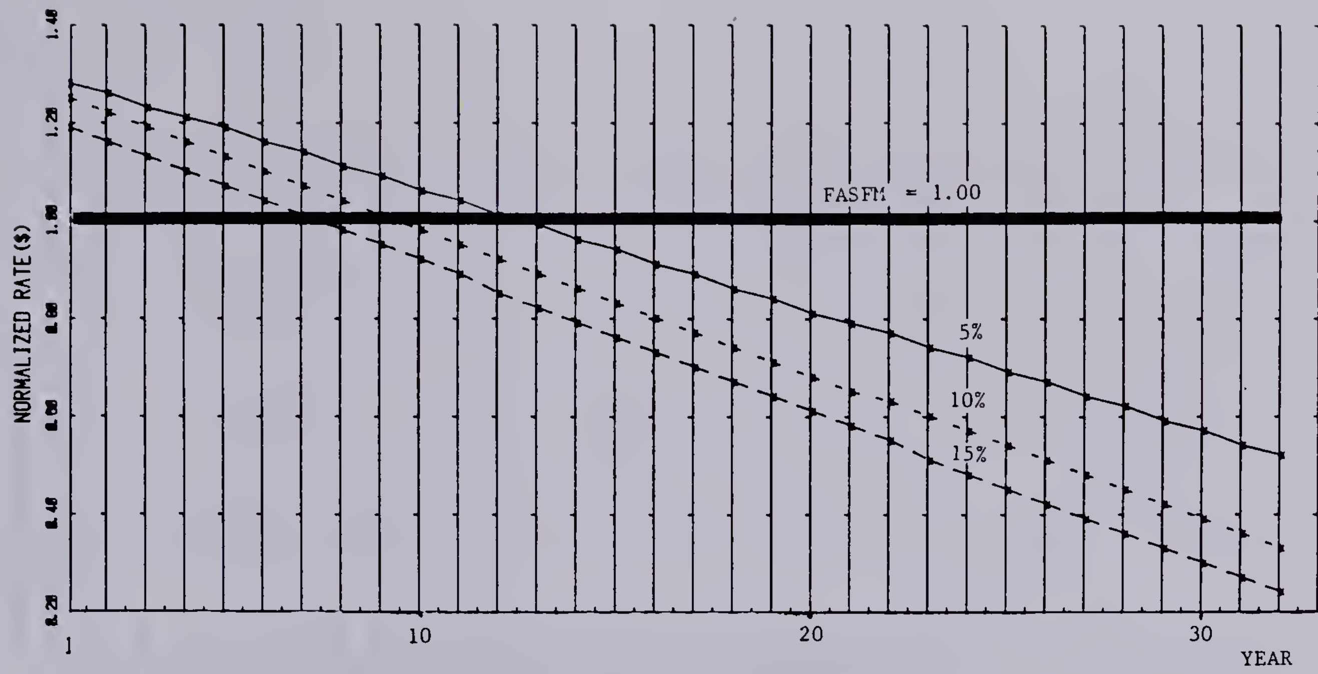


Figure 4.1.2 (b)

Comparative Normalized Price
For Various Interest Rates

For the highest interest rate (15%), the Straight Line price which would exactly cover costs in year one would be $18,125 as compared to the proper price of $15,173 using FASFM, or 28% higher (i.e. normalized rate of $1.28). By contrast, at the end of the life, the Straight Line price is $3,594 or 24% of the FASFM price.

3) Depreciation Expense

The FASFM uses change in economic value (present worth of all future receipts) as its measure of depreciation. For high interest rates, the change in economic value is very small in the early years. Also, since the additional interest expense raises overall price levels, the economic value changes more rapidly in the last few years as the discounting is done over a shorter period.

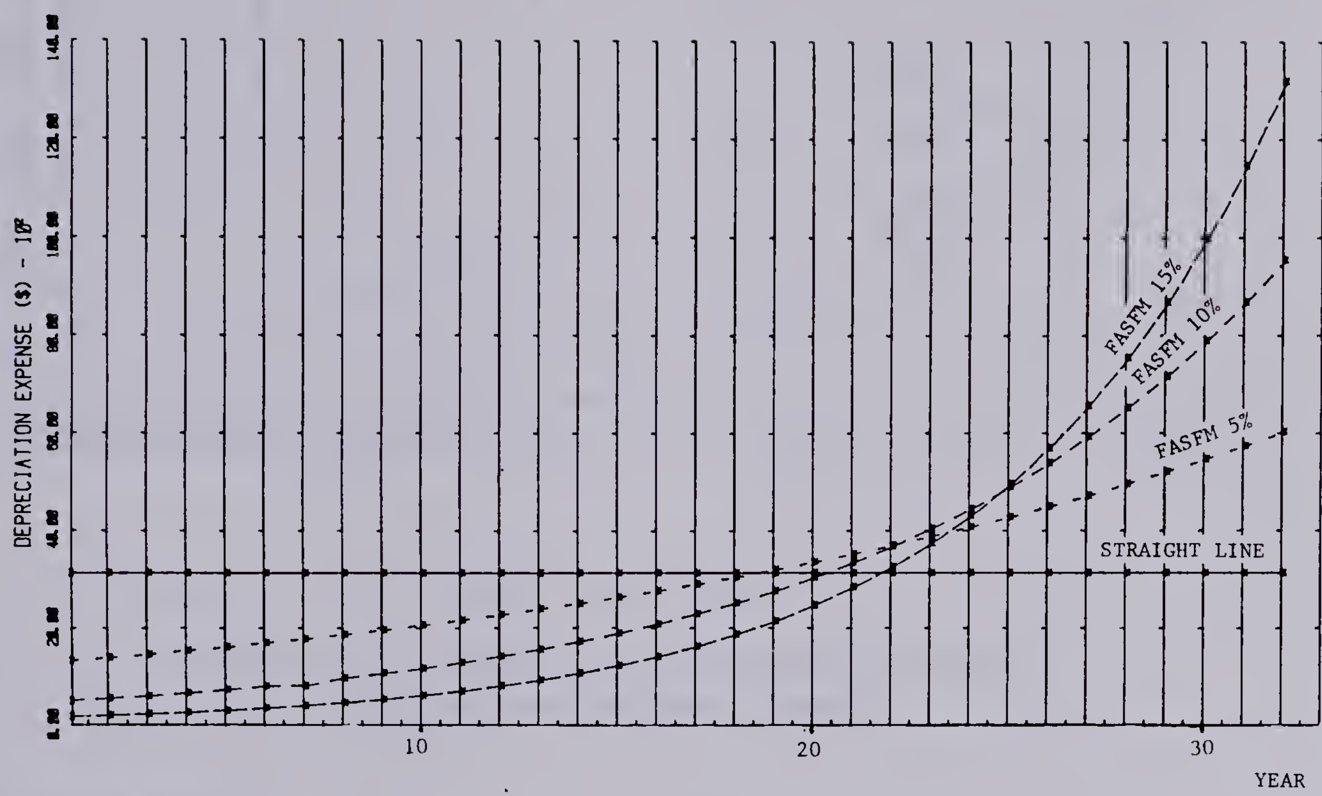


Figure 4.1.3 (a)

Comparison of Depreciation Expense
For Various Interest Rates

Also worth noting is that, as the interest rate goes higher, the year in which the two methods crossover increases (year 19 for 5%, year 22 for 15%) (see Figure 4.1.3 (a)). Both crossovers exceed the half service life of 16 (ie. 32/2) years.

Figure 4.1.3 (b) shows the cumulative depreciation pattern for the various interest rates. It very dramatically displays how the depreciation expense is increasingly deferred by the higher interest rates.

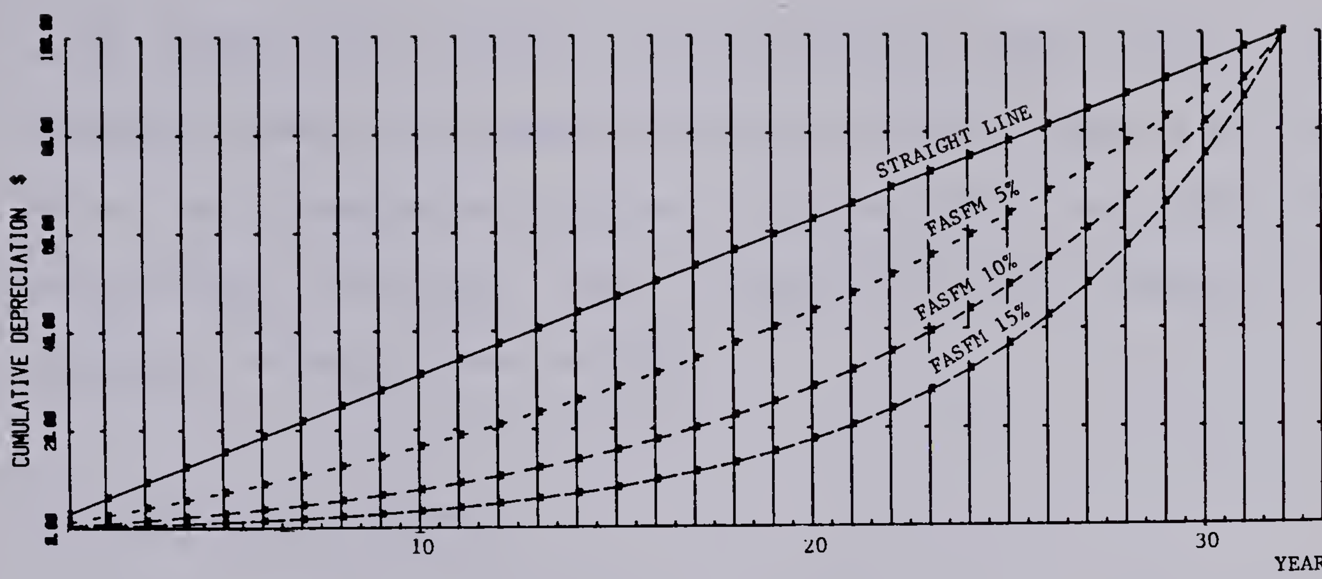


Figure 4.1.3 (b)

Comparison of Cumulative Depreciation Expense
For Various Interest Rates

4.2 SERVICE LIFE

Assets in the utility industry have widely varying service lives, anywhere from 2 to 100 years.

Table 4.1

Selected Typical Service Lives

ASSET	LIFE
Telephone Subscriber Equipment *	10
Telephone Central Office Equipment - Digital	45
Telephone Aerial Cable	17
Telephone Underground Conduit	55
Water Treatment Plant	55
Transmission Mains	77
Distribution Mains	88
Meters	15
Power Generating Station	25
Power Pole	30
Transformer	30

* All data from the City of Edmonton

As the service life increases, the discrepancy between the two test methods increases. To compare the various service lives on the same scale, an illustrative tool was borrowed from the group life depreciation techniques. Age is expressed in this method as a percentage of average service life.

1) Apparent Net Income

The apparent net income starts off less negative and ends up more positive for longer-lived than for shorter-lived assets (see Figure 4.2.1). Also, as the life is extended, the accounting rate of return crossover between methods, as a function of percentage of service life, actually shifts to the left with age (40-60% for a 5 year asset, 65% for a 40 year asset). This results from the fact that depreciation becomes a less and less important component of rates as life increases. In the earlier years, the interest component is more dominant for longer-lived assets. In the latter part of an asset's life, the undepreciated part of the asset, essentially the outstanding capital, becomes very small making the accounting rate of return excessively large.

2) Price

Because of the differing service lives, comparison of the actual price does not provide a true picture of the effect of service life on the discrepancy measures. However, the comparison of

normalized price vividly shows the impact service life has on price.

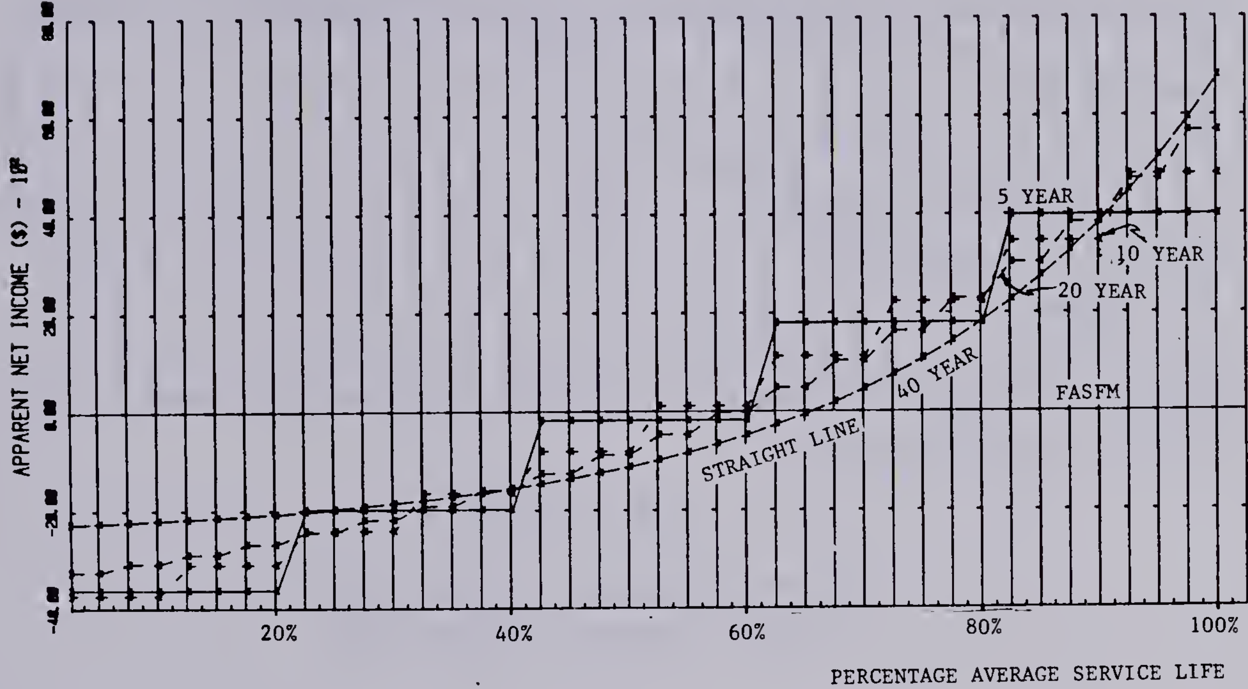


Figure 4.2.1

Comparison of Apparent Net Income
For Various Service Lives

Unlike increases in interest rate, increasing an asset's life creates a progressively lower price in early periods.

In terms of percentage of service life, rather than actual years, the price for longer-lived assets crosses over sooner than for shorter-lived assets. These prices continue to get progressively more distorted, however, over the life of the asset. Because the different service lives have different resolution (one year equals 10% for 10 years but only 2.5% for 40 year assets) the cross-overs are not as pronounced in the early years. Also as the life gets longer, the depreciation component approaches zero and for very long-lived assets, would lose all its effects.

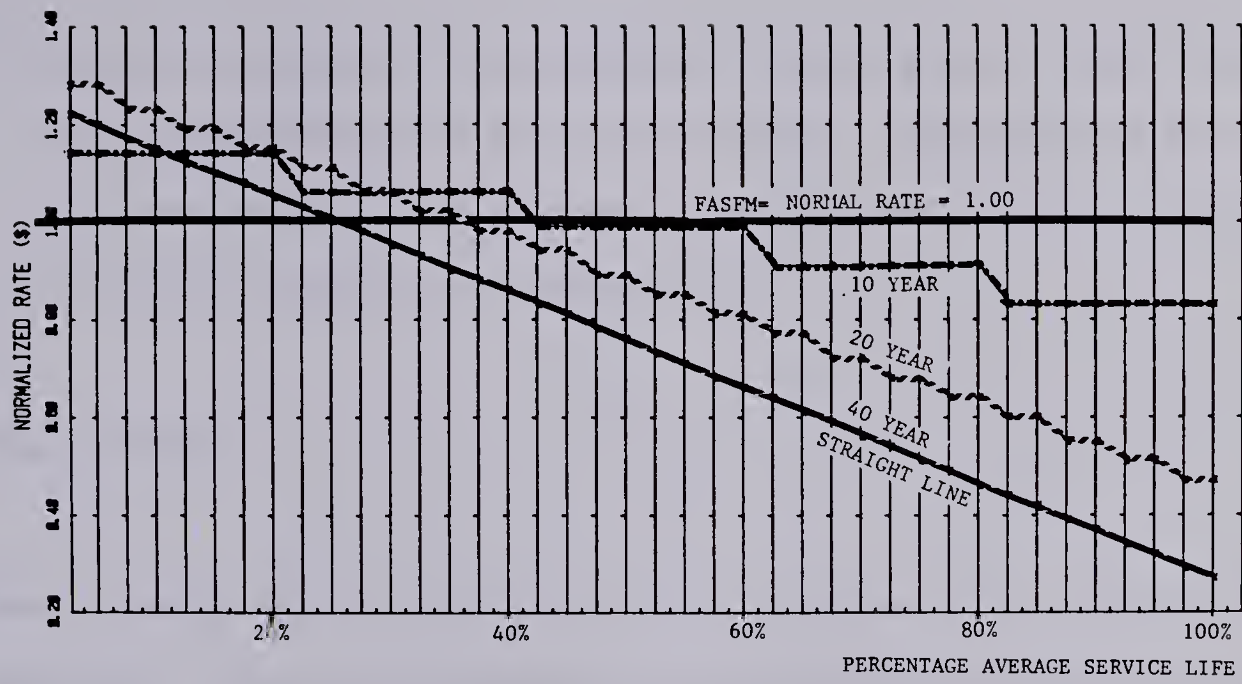


Figure 4.2.2

Comparison of Normalized Rates
For Various Service Lives

Figure 4.2.2 shows very vividly the amount of cross-subsidization the early years of an asset can contribute to later years. In essence, the overcharging in early years is invested at the internal rate of return and then drawn out after the cross-over to lower the already low rates even further.

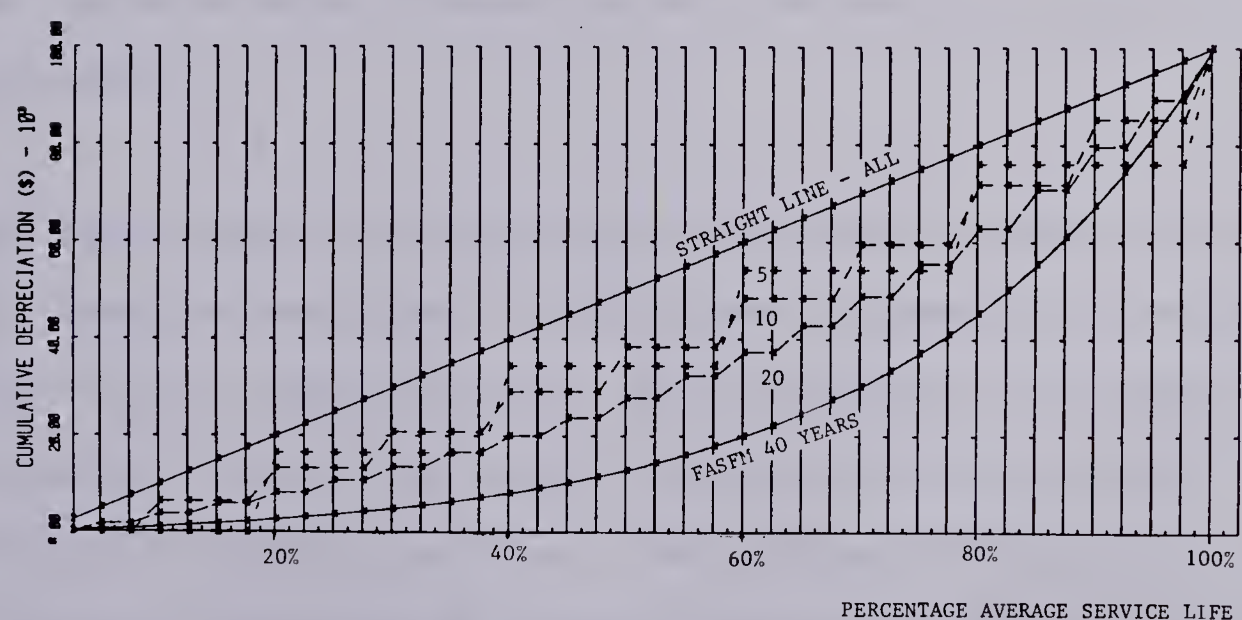


Figure 4.2.3

Comparison of Cumulative Depreciation
For Various Service Lives

Similar to interest rate increases, longer service lives cause a higher discounting of final year revenues, lowering the loss of economic value in early years. This manifests itself in Figure 4.2.3 as a deferral of depreciation.

4.3 FILL PROFILE

Assets may be divided into two broad categories, those having "unit capacity", such as a telephone or a water meter, and those having "multi-unit capacity", like a telephone switching centre.

Because monopoly utility companies can fairly accurately forecast demand for their services and because of great economies of scale inherent in the provision of some central functions, the utility often purchases excess capacity in anticipation of future demand. This "multi-unit capacity" can range from 3 or 4 units in a small key system to several thousand units in the case of a central office extension.

The excess capacity can be exhausted over time in various patterns. The amount of assets used in any one year compared to the available capacity is called the "fill" and is expressed as percentage of capacity. The fill of assets can change over the lifetime in a variety of different patterns. Each different fill pattern will result in a substantially different depreciation expense allocation to each year using the FASFM. The Straight Line Method remains unchanged by various fill patterns. To demonstrate these effects,

three different theoretical profiles are run through the model (see Figure 4.3.1).

1) Profile A - Constant Fill

Typical of "unit capacity" assets, once a unit is put into service, it remains totally "full" until it is retired.

2) Profile B - Constant Growth to Design Capacity

After an asset is placed into service, it continues to fill up gradually until it reaches the design limit (usually somewhat lower than physical capacity) and continues at that fill until final retirement. For this example the asset will be full by the time it has reached 25% of its service life.

3) Profile C - Constant growth to capacity, maturity, then constant unfilling to end of service life.

The asset gradually approaches its ultimate capacity. After a time of mature fill, the usage falls off gradually, because of obsolesence, or otherwise, until it is retired. For this example, the asset reaches ultimate fill after 25% of its service life and then, at 75% of its service life, gradually serves fewer customers until it finally retires.

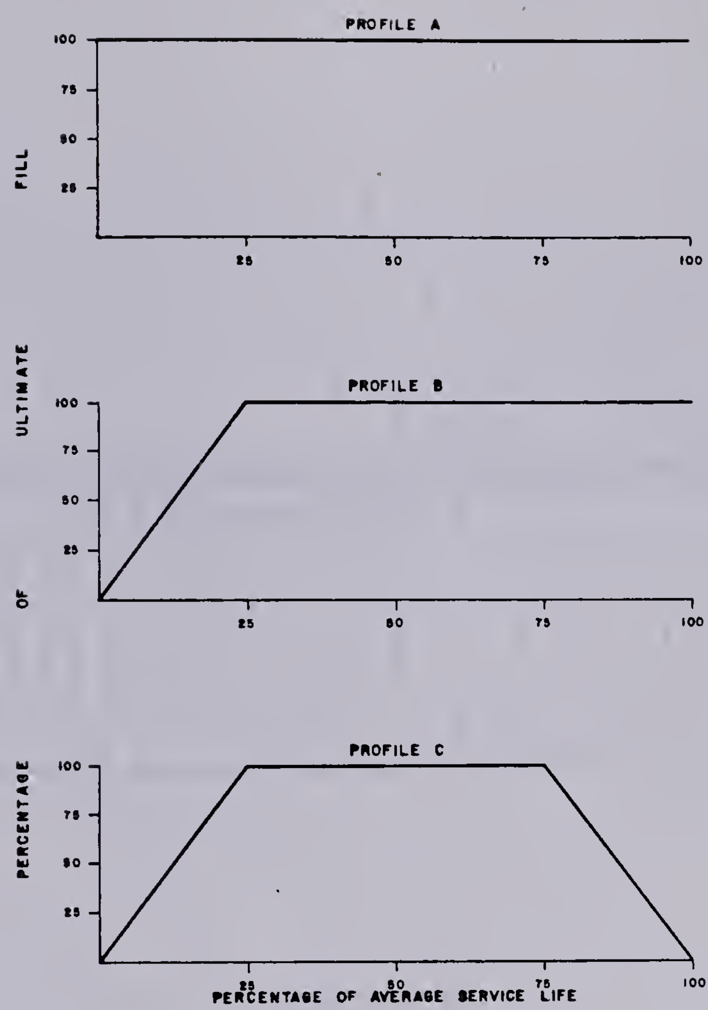


Figure 4.3.1

Various Fill Profiles

In the early years of Profile B and Profile C fill patterns, quite typical of many assets, the net income using constant prices would appear to be extremely low, signalling the regulator that a healthy increase was in order. (See Figure 4.3.2).

The slower the unit fills up, the more dramatic is this apparent short fall.

For the Profile C pattern, the net income abruptly drops off as the consumption of that asset falls. Even if this were a normal occurrence, the Straight Line Method would have no way of adjusting management accounting information for it.

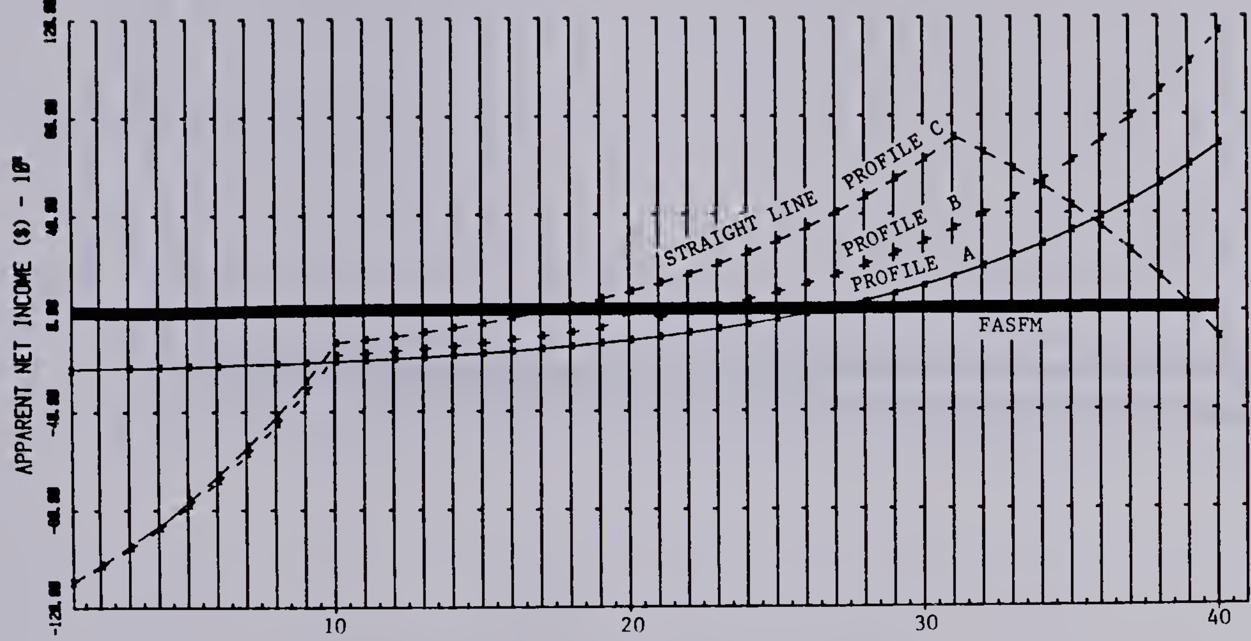


Figure 4.3.2

Comparison of Apparent Net Income
For Various Fill Profiles

Keeping in step, the price required to equalize traditional net income and rate of return would be extraordinary. In this example, the price necessary to meet revenue requirements using the straight Line Method is 8 times larger than they need to be in the first year using the FASFM. Notice that in spite of the large variation in customers between years, the FASFM rates are identical in each year.

The depreciation expense follows a pattern similar to the net income. Notice that the Straight Line Method yields identical depreciation regardless of fill profile. However, the FASFM adjusts its depreciation depending on the future fill pattern.

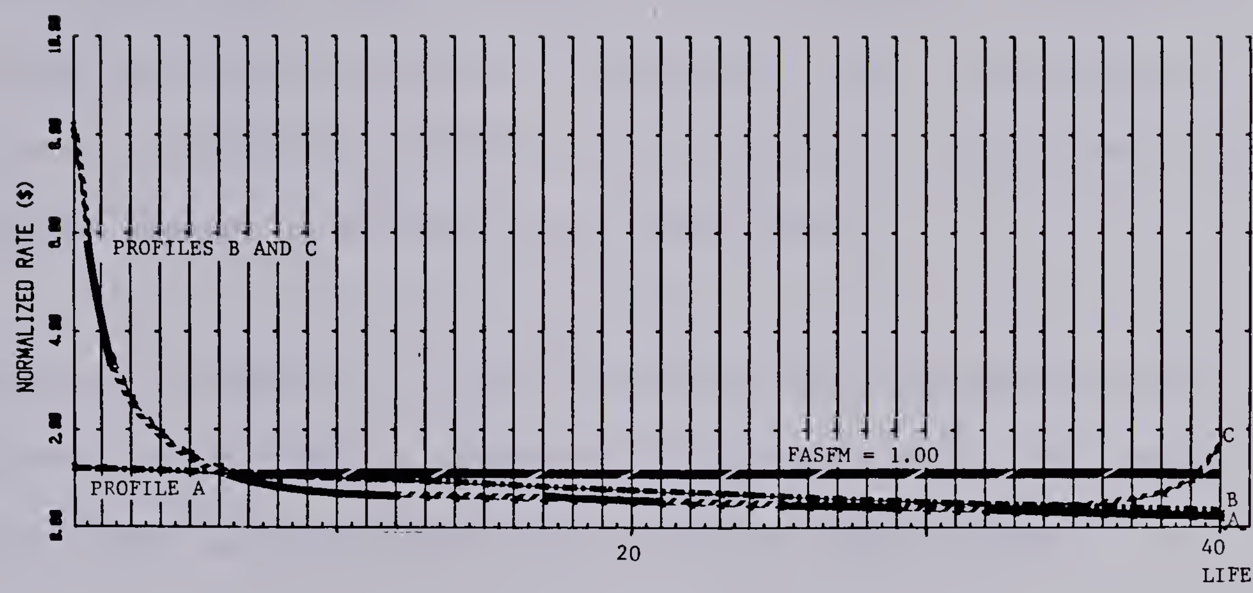


Figure 4.3.3

Comparison of Normalized Rates
For Various Fill Profiles

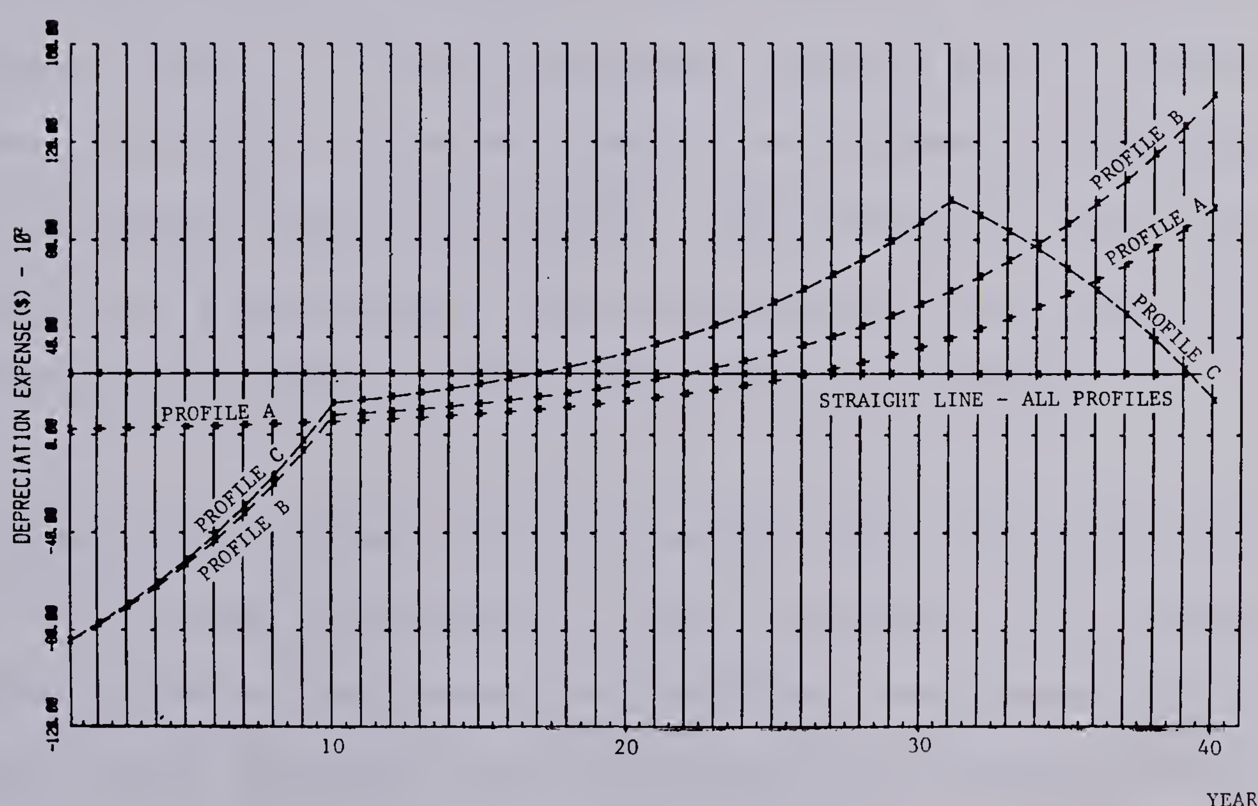


Figure 4.3.4

Comparison of Depreciation Expense
For Various Fill Profiles

Because the latter year revenues are diminishing, consequently lowering the economic worth of those years, most depreciation is collected before the decline; years where the revenues, and therefore changes in economic worth, were high.

Since this parameter is not now used for depreciation work, engineers would have to estimate, by account code, the average designed fill pattern if they were to use the FASFM method.

4.4 GROWTH RATE

By definition, over the life of an asset, the same amount of money must be extracted from the totality of customers under either depreciation method. In all the above examples, the distortion caused by using the Straight Line Method takes the form of a timing error. Typically, in the early years, the customer is overpaying and in the later years, underpaying. This "discrepancy life-cycle" becomes more pronounced with higher interest rates and longer life and continues beyond the "half-service life" of the asset.

If enough assets are past this "turn-around" point, they will cancel out the opposite discrepancies of the new assets. By contrast, during periods of high growth and inflation, the average life is biased towards the earlier years where the large overpayment exists.

Growth rate and the next parameter, survivor curve shape, are the only two which show the "mix" effects of adding different aged assets together in different combinations.

For illustration, three types of rates of growth will be examined, each having a 30 year life (see Figure 4.4.1):

1) steady state
2) constant linear growth
3) constant exponential growth

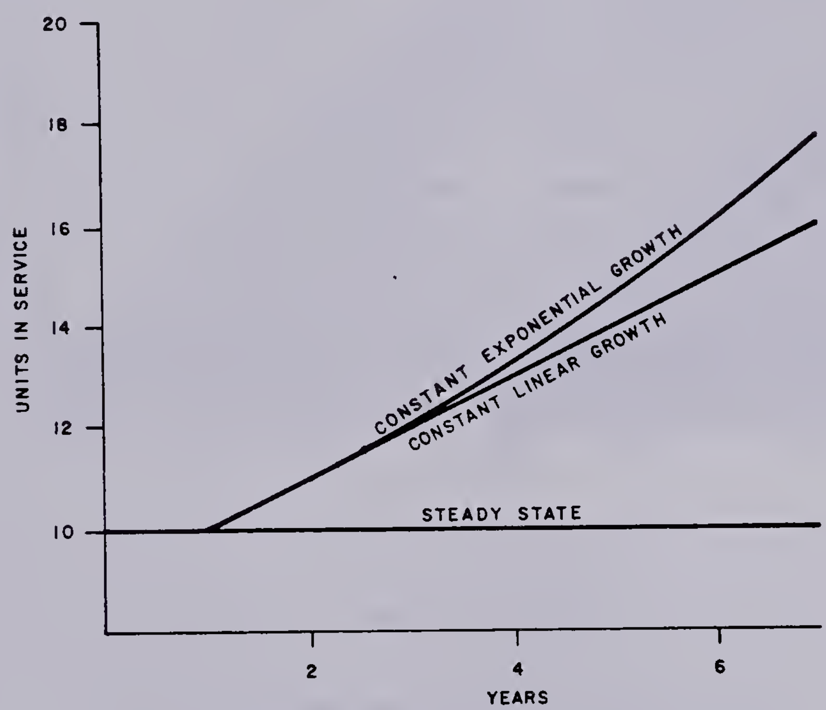


Figure 4.4.1

Types of Growth

4.4.1 Steady State

At first glance, steady state, where retirements are equal to additions, would appear to be a trivial case, since it would seem that the system should be stable. In actual fact, the depreciation pattern could be very complicated, depending on the original distribution of asset ages. Therefore, this demonstration is split into three sub-types, all requiring thirty units for a thirty year

life:

1) Assuming that in the distant past (more than one life cycle), assets were added such that they now wear out and are replaced at a uniform rate, say every year (see Figure 4.4.2.).

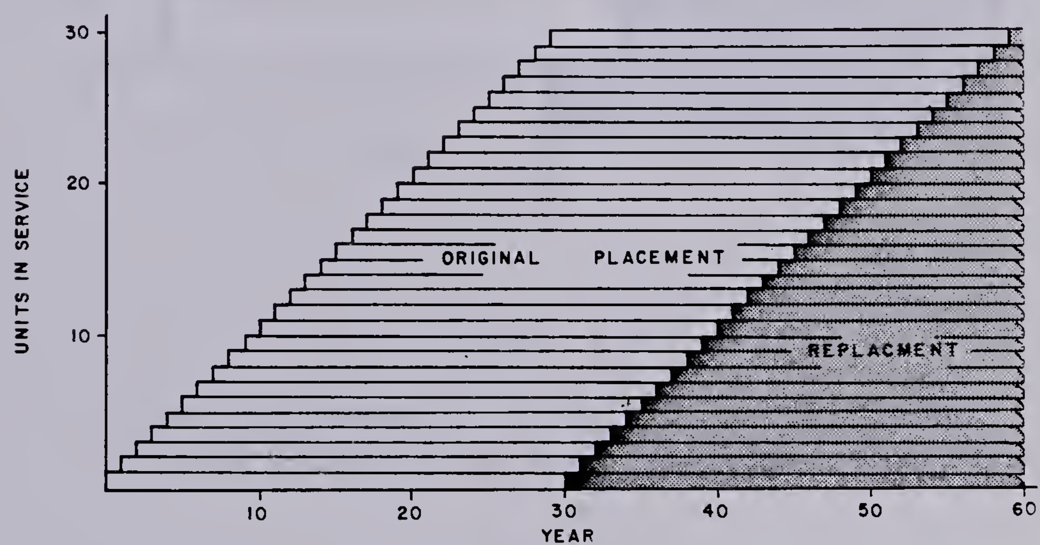


Figure 4.4.2

Graphic Illustration of Steady State Growth
Uniform Original Placement

2) Assuming that the assets were originally placed in service at a rate of five units, once every six years (see Figure 4.4.3).

Although this pattern would normally not occur indefinitely, it is conceivable that in certain circumstances, assets could be placed with this economic interval.

3) Assuming that all assets were originally placed in service simultaneously and that they will all have to be replaced at the same time. (See Figure 4.4.4). This scenario would be a "worst

case", showing the upper limit of distortion.

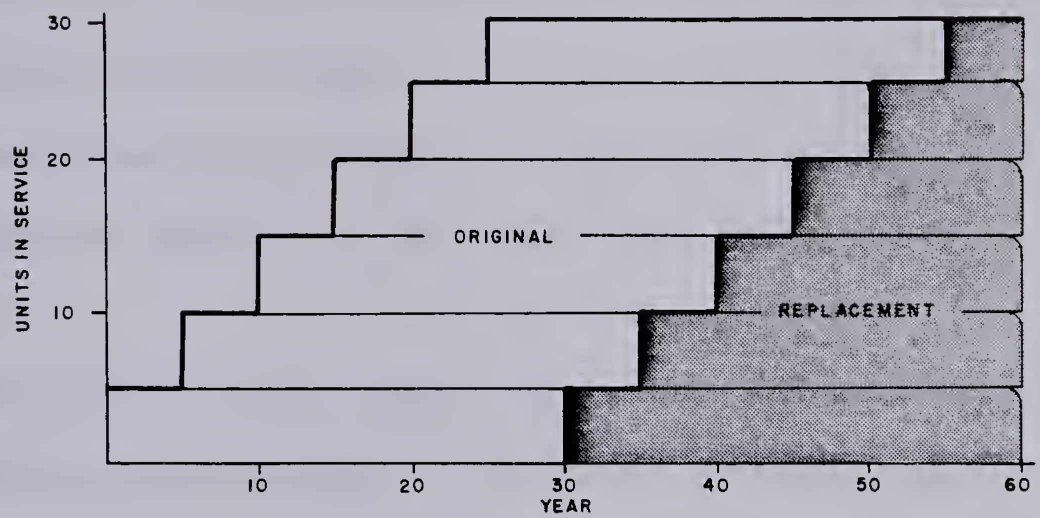


Figure 4.4.3

Graphic Illustration of Steady State Growth
Original Placement of Five Units Every Six Years

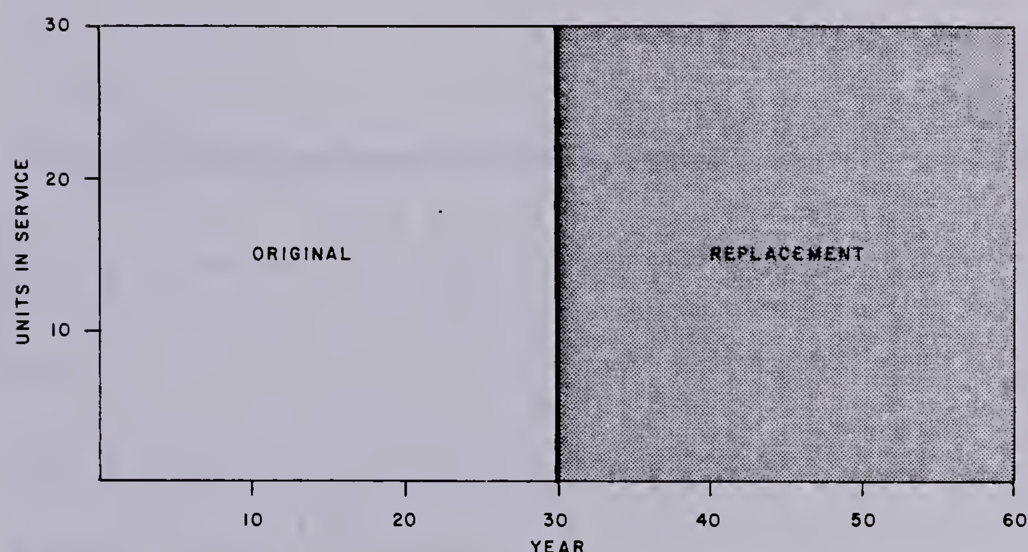


Figure 4.4.4

Graphic Illustration of Steady State Growth
Original Placement of 30 Units

In order to see the total range of affects, it is important to carry on the analysis for at least one full life span (30 years). The

graphs of normalized revenues and depreciation expense are shown for years subsequent to achieving this steady state (>30 years). By then, the previous overcharging would have created a permanent distortion in future rates such that, even with the uniform distribution of placement of assets, the steady state Straight Line price is only 80% of the steady state FASFM price.

For the uniform mix case, oscillations are essentially non-existant, making the two depreciation methods virtually equal. However, from Figure 4.4.5, one can see that the more "lumpy" the investment pattern, the higher the amplitude of the fluctuations in all parameters, and the lower the frequency.

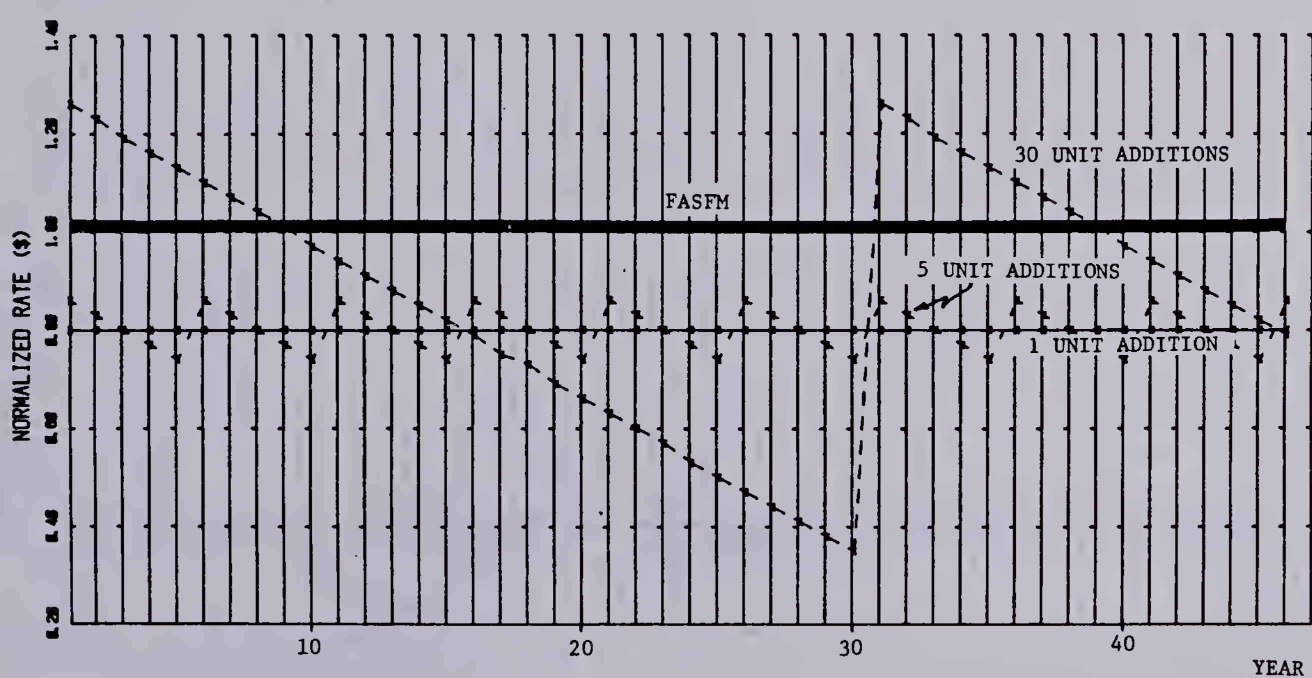


Figure 4.4.5

Comparison of Normalized Rates
For Various Replacement Patterns
In Steady State

If a regulator were using the straight-line method, and a single test year to set rates in these circumstances, he would constantly be ordering modifications to rates, sometimes up, sometimes down. It is in this system, which is, by definition, stable, that the inadequacies of the present system are most obvious.

The FASFM compensates for the inherent fluctuations of the Straight Line Method by essentially creating an offsetting adjustment through the depreciation expense. While the FASFM pattern looks more intricate, it actually creates a stable net income (of zero, after cost of money) which would be infinitely more informative to a regulator looking to stabilize rates.

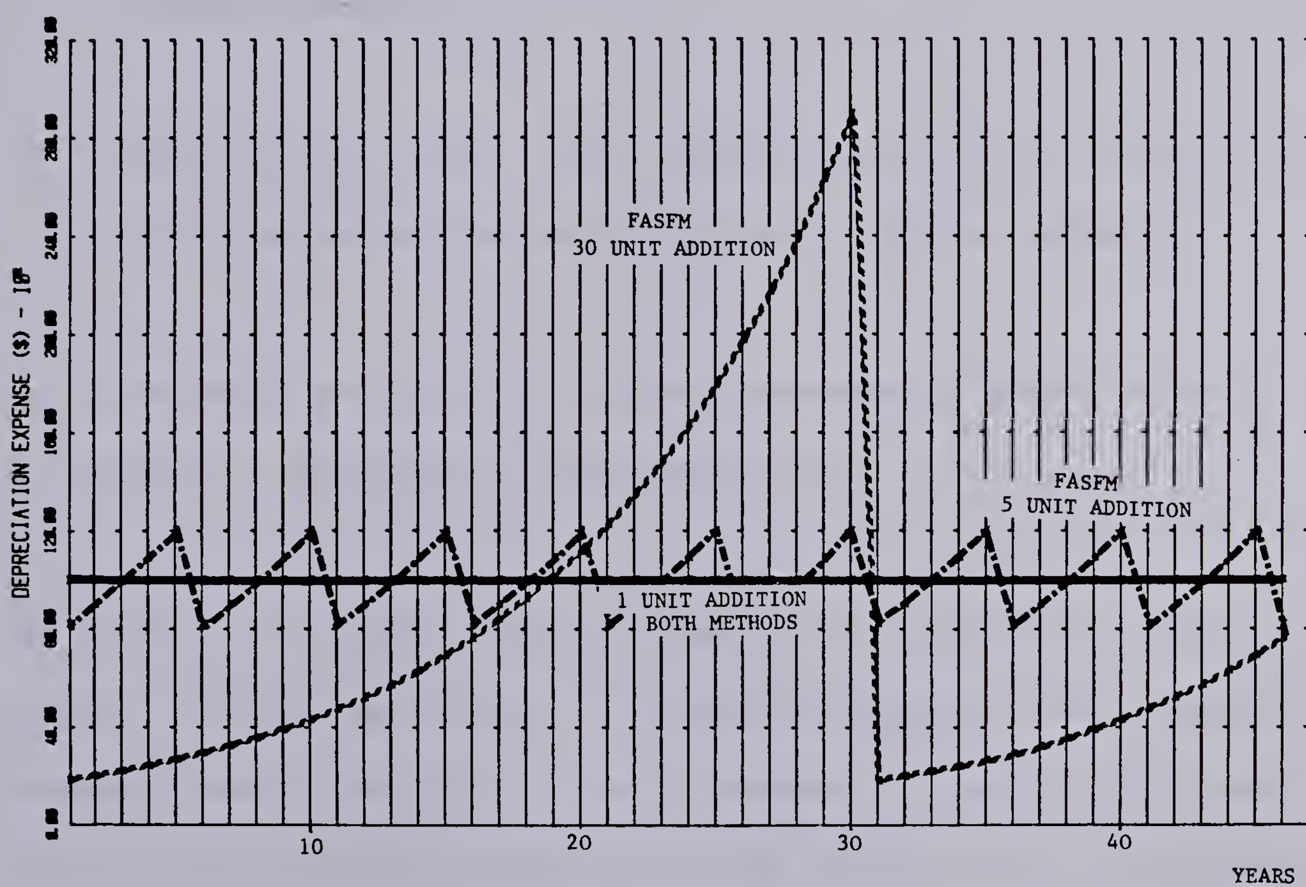


Figure 4.4.6

Comparison of Depreciation Expense
For Various Replacement Patterns
In Steady State

4.4.2 Constant Linear Growth

To isolate the effect of this component from the previous effects, the least oscillating base vintage mix, namely the uniform distribution of vintages, is used. From there, it will be assumed that the demand for production capacity grows at a constant rate, and that the constant growth is met in each year rather than by lumpy additions. To show the effect of different sizes of growth relative to the base, three levels of growth are used:

1) One unit per year - on a base of 30 units, this would initially represent a 3.3% growth, a lower level than expected in the telephone industry.

2) Three units per year - this would represent the typical growth of 10% now being experienced by most telephone companies.

3) Five units per year - this would represent a growth of 16.7% and would be considered a high growth rate.

As could be expected, the rates suffer more distortion under high growth. First, as the mix of assets becomes biased towards the younger assets, the price rises. Eventually, and slightly earlier for the higher growth assets, the bias shifts back to more heavily weight the older, lower priced assets. As would be expected, this continues until all the rates are back to normal steady state condition (= 80% of FASFM rates).

However, a less expected event occurs at the time when the assets come due for replacement. As in the steady state case, the effect of an original placement is repeated during each subsequent replacement. But this time, the "echo" of the original shock is damped, since relative to new growth, it is not as large a proportion of total assets as it was at the time of its first placement.

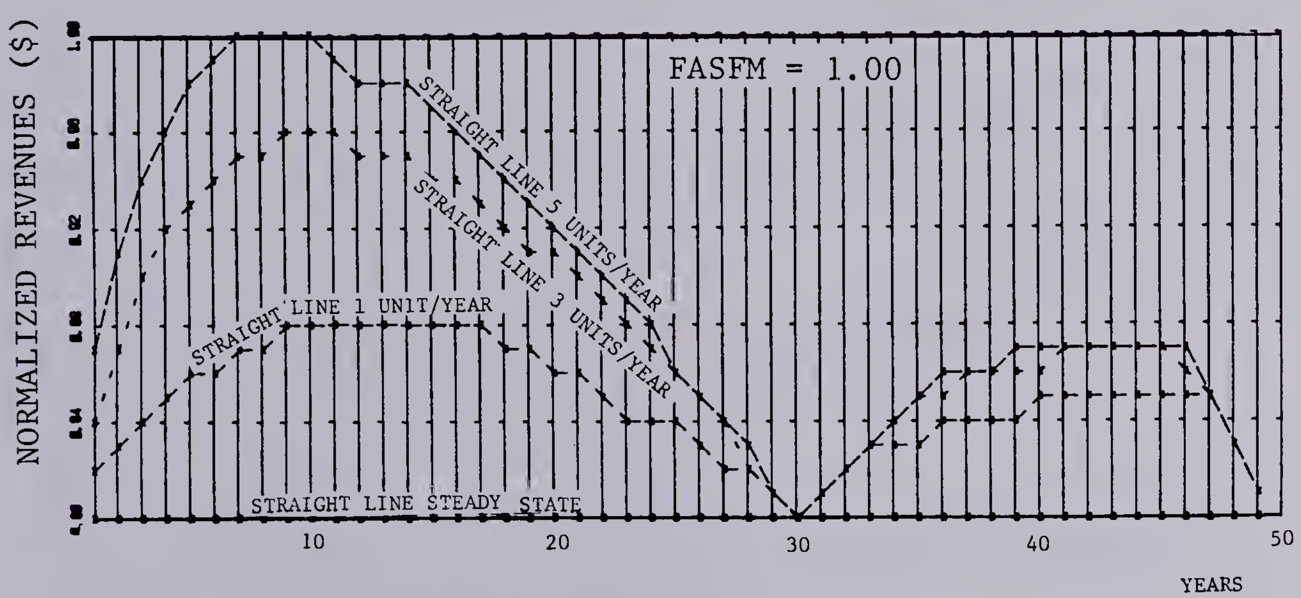


Figure 4.4.7

Comparison of Normalized Revenues
For Various Levels of Constant Linear Growth

Similarly, depreciation expense is increasingly distorted as growth rate is increased. It is interesting to note that, for all growth rates, the discrepancy reaches zero at each thirty year interval when the FASFM depreciation expense just catches up to the Straight Line Method. The next year, the requirement for replacement of assets starts the cycle over again.

If the asset growth is interrupted, as it is in this example, the Straight Line depreciation immediately begins to decline. However, the FASFM depreciation, being biased towards the later years of assets, continues to climb for a short while before it too falls off.

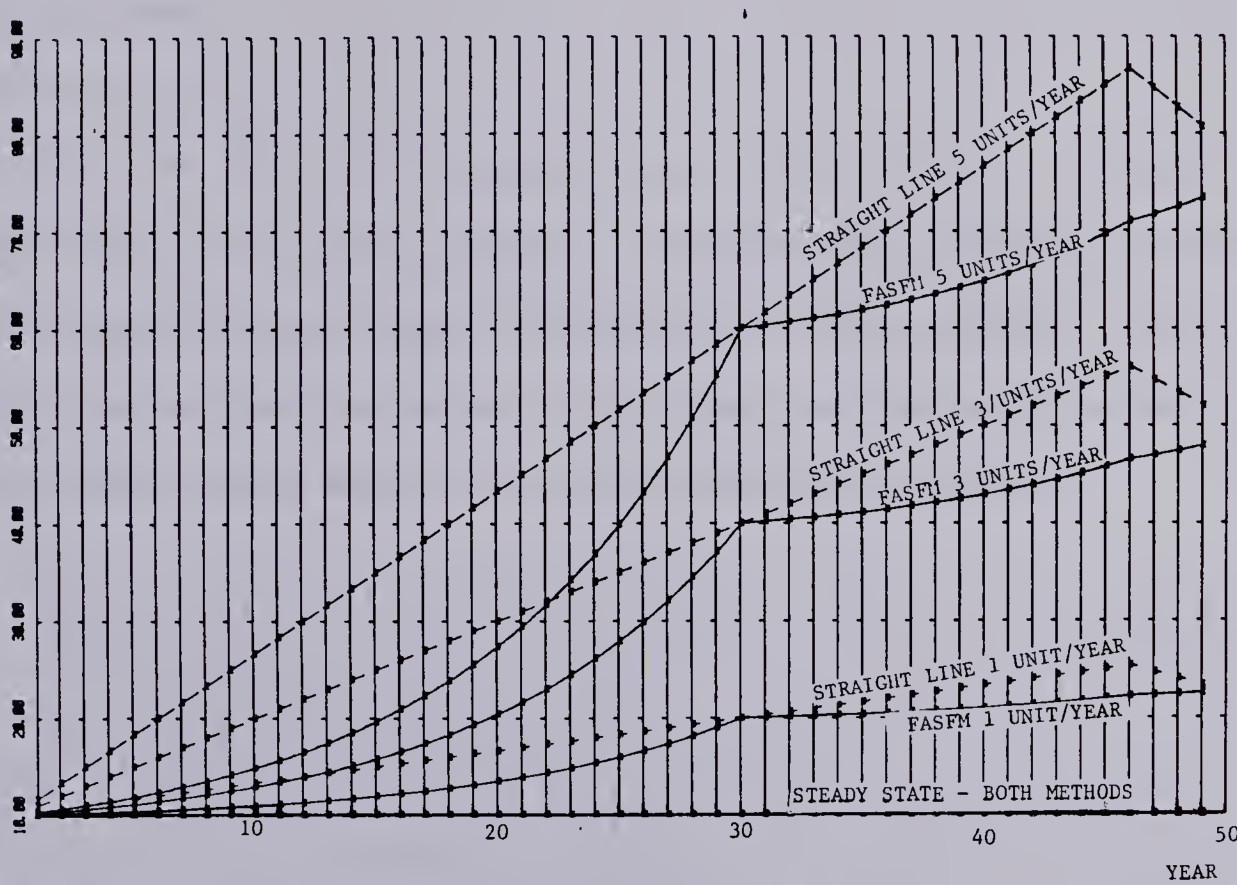


Figure 4.4.8

Comparison of Depreciation Expense
For Various Levels of Constant Linear Growth

It is interesting to note that even under a situation of high linear growth, eventually the system catches up and makes the FASFM prices appear too high.

4.4.3 Constant Rate of Exponential Growth

The third type is a constant rate of growth and again it will be assumed that the base is uniformly aged. Growth is tested at the same percentage as above, namely:

1) 3.3%,
2) 10%, and
3) 16.7%,

but will be based on the prior year rather than on a base year. Compared to the constant growth, the exponential growth results in a much more rapid and larger initial distortion in prices. The price using large growth rates starts to head back downwards sooner than the lesser growth rate but does not diminish as steeply.

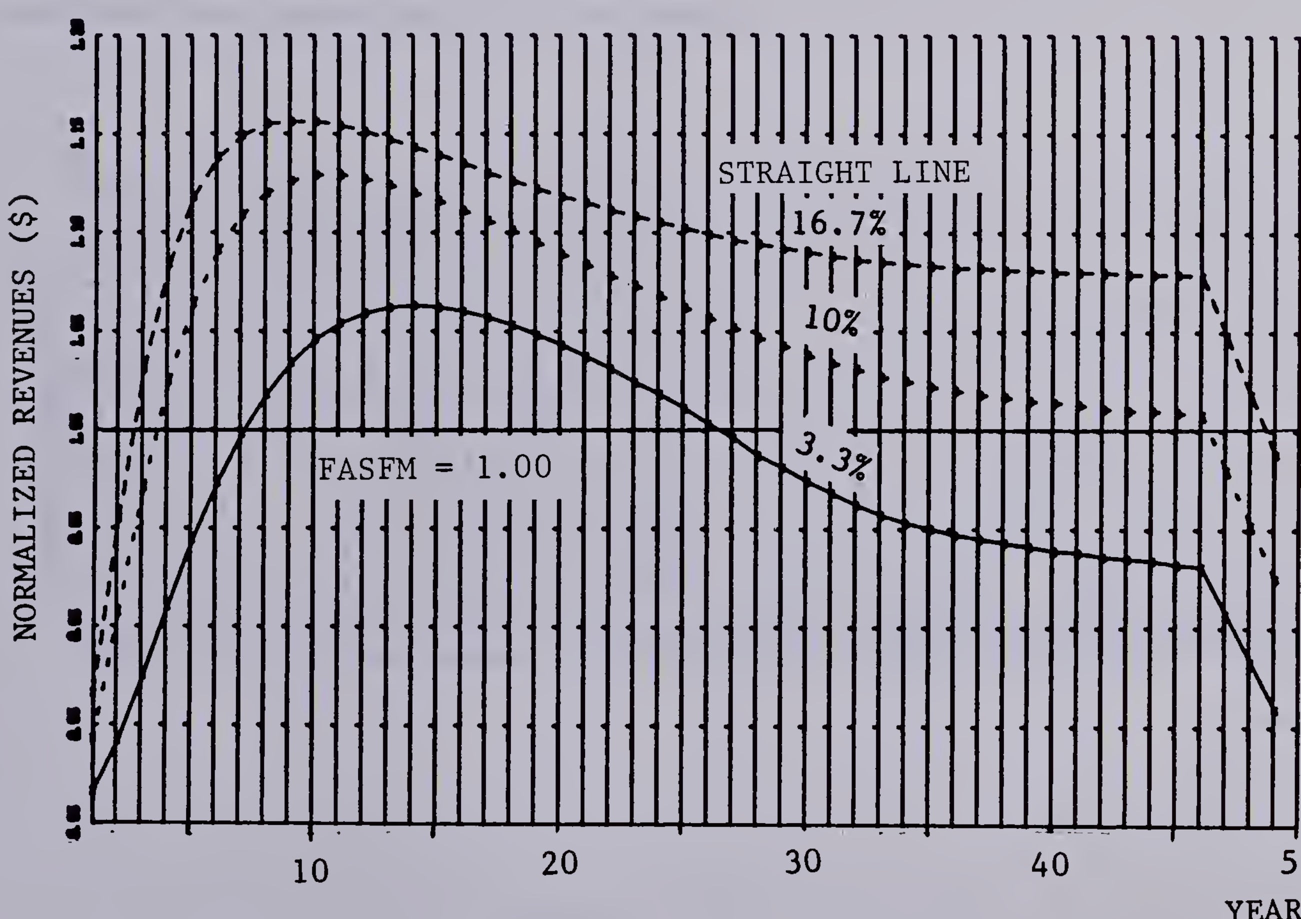


Figure 4.4.9

Comparison of Normalized Revenue
For Various Levels of Constant Exponential Growth

The higher the rate of growth, the longer this series will take to stabilize. In fact, if the rate of growth is high enough to move the point of stability beyond one life cycle, it will cause the instability to remain indefinitely.

If the growth were suddenly terminated, as it was in year forty-five in this example, the rates would all suddenly plummet, with the largest growth rate pattern having the steepest descent.

Similarly, the depreciation expense is distorted by the growth rate. The higher the growth, the greater the discrepancy between the methods. Unfortunately, by the nature of exponential growth, the discrepancies in earlier years are made insignificantly small by the enormous discrepancies in later years.

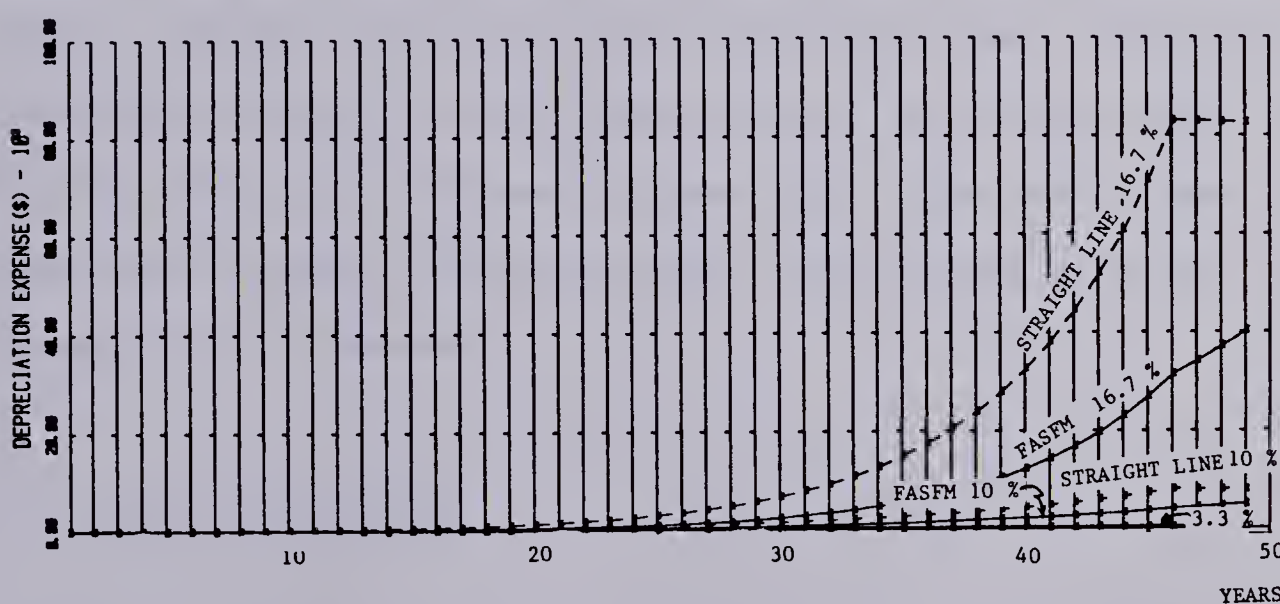


Figure 4.4.10

Comparison of Depreciation Expense
For Various Levels of Constant Exponential Growth

4.5 MORTALITY CURVES

This section will describe the historical development of survivor curves for utility assets and the effect of these curves on the measures of discrepancy between Straight Line and FASFM depreciation using various curve parameters.

4.5.0 Historical Development of Mortality Curves

At the turn of the century, when telephony was not so complicated, accountants estimated an average age for the total spectrum of assets, en masse, instead of the ideal of depreciating each asset separately. As the complexity and multiplicity of assets increased, they realized that the depreciation expense could be made more accurate if the assets were split into more "life-homogeneous" groups. As the quest for accuracy became more keen, these asset groups were further split into sub-accounts. Another refinement was to split them into various vintages and calculate a separate depreciation schedule for each vintage. This method is called the Vintage Group (VG) Method.

1) Vintage Groups Method

To determine the yearly depreciation rate, an average service life is calculated for the vintage group by dividing an estimate of the total unit-years by the number of remaining units. Figure 4.5.1 illustrates a single vintage consisting of five

units all placed in the same year but estimated to last 1,2,3,4 and 5 years respectively. The total expected unit-years of service would therefore be 15 (ie. 1+2+3+4+5) or an average of 3 (ie. 15/5) years per unit. This would result in a depreciation rate of 33.3% per year on each remaining unit or $100 per unit per year.

All five units would exist during the first year, resulting in (5 x $100 =) $500 of expense. By the end of the fifth year, exactly all of the assets' value would have been expensed in the manner shown in Figure 4.5.4.

	Unit 1	100				
	Unit 2	100	100			
	Unit 3	100	100	100		
	Unit 4	100	100	100	100	
	Unit 5	100	100	100	100	100
		1	2	3	4	5 Year
Remaining Plant		1500	1200	900	600	300
Depreciation Expense		500	400	300	200	100
%		33.3	33.3	33.3	33.3	33.3

Figure 4.5.1

Pictorial Representation of the Straight Line Vintage Group (VG) Depreciation Method

In a sense, only $100 has been accrued from the unit which lasted only one year. This results in a shortage of $200 for the first year. Conversely, by the end of year 5, the asset left will have accumulated an accrual of $500, when, in fact, it only cost $300. This anomaly leads to the creation of the next depreciation technique, the Equal Life Group Method.

2) Equal Life Group

The Equal Life Group (ELG) Method takes one more step towards the ideal of one account for each asset. In a group of one vintage of assets, some assets will have shorter lives and some longer. The ELG method groups these assets into their respective expected lives and effectively allocates each of their capital costs across their respective life spans. That is, all the assets with a one year life get charged over one year; all the two year assets get charged over two years, and so on.

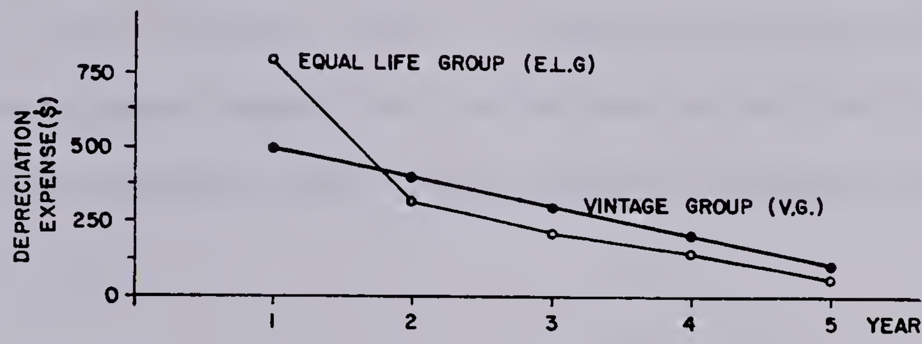
The pattern of depreciation expense would be as outlined in Figure 4.5.2.

Unit 1	300				
Unit 2	150	150			
Unit 3	100	100	100		
Unit 4	75	75	75	75	
Unit 5	60	60	60	60	60
Year	1	2	3	4	5
Remaining Plant	1500	1200	900	600	300
Depreciation Expense	685	385	235	135	60
%	45.7	32.1	26.1	22.5	20.0

Figure 4.5.2

Pictorial Representation of
Equal Life Group (ELG)[2]
Depreciation Method

The method would result in a more accelerated depreciation than the VG method, as represented graphically in Figure 4.5.3.



VG	500	400	300	200	100
ELG	785	385	235	135	60
Difference	-285	15	65	65	40

Figure 4.5.3

Comparison of VG and ELG
Group Depreciation Methods

The example above was, for illustrative purposes, intentionally simple. If the number of assets in a category were small, it would be possible to apply the ELG Method discretely. However, as the number of assets and their service lives increased, the magnitude of the depreciation calculations would soon become unbearably large.

Fortunately, as the number of units increases, so does the opportunity to apply statistical methods to the data. One such application was studied in depth at the Iowa State University under the direction of Robley Winfrey during a period spanning three decades from 1922 to 1952.

In the first years of his study, he met a Professor Edwin B. Kurtz who applied an actuarial approach from the insurance industry to property depreciation. He calculated "survivor curves" for various types of physical properties. These survivor curves showed the percentage of original units still surviving each year after their original placement (see Figure 4.5.4).

Winfrey contined Kurtz' work, performing several transformations on the data in his quest to find patterns in the myriad data he and Kurtz had compiled.

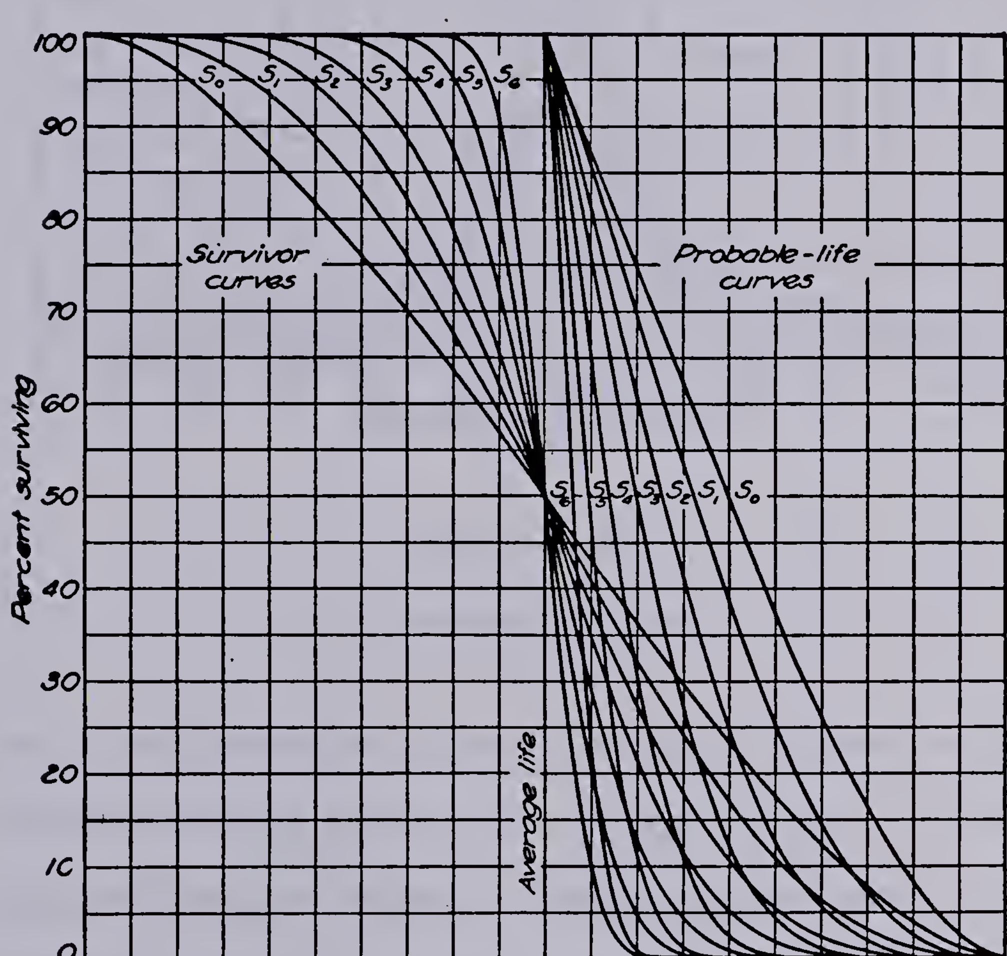


Figure 4.5.4

Typical Survivor Curve

First, instead of expressing the survivor curves in absolute years, he expressed age as a percentage of average service life. This allowed him to compare the curves of assets of varying longevity. Still, the distinction between curves was obscured by the steep slopes of the various data. He calculated the first derivative of the survivor curves and called it the frequency curve. It showed the number of retirements during each year of the asset's life (see Figure 4.5.5).

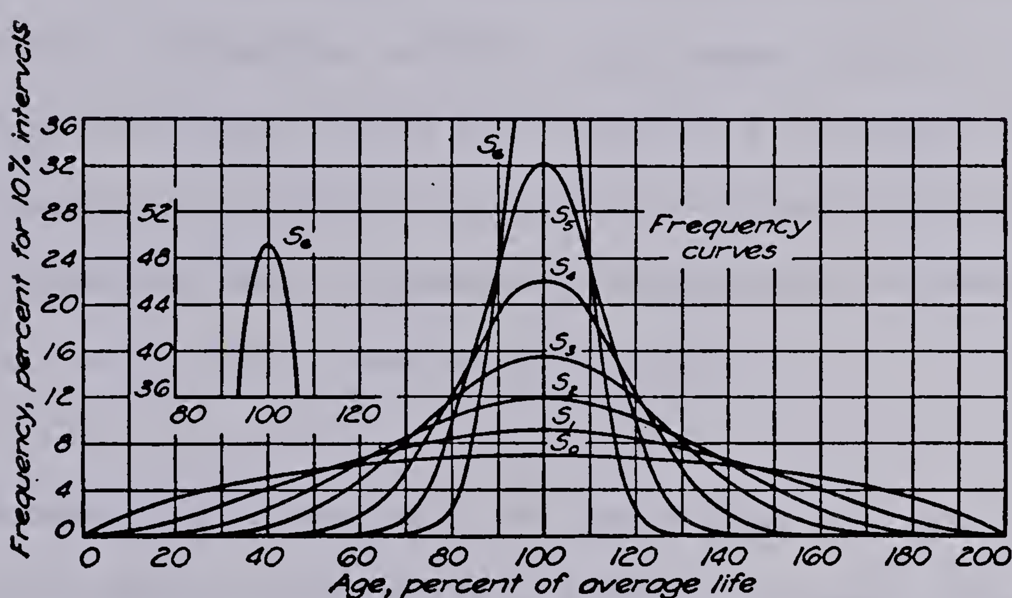


Figure 4.5.5

Frequency Curve

As a differential curve, it more dramatically protrayed differences and similarities between curves. The first mark of distinction was found by analyzing the mode of the frequency curve.

In certain assets, the mode occurred to the left of the average life. On others, the mode coincided with the average life. In the last category, the mode was to the right of the average

life. These groups were designated left modal, symmetrical and right modal, respectively.

The second feature of the curves was the relative height of the mode. Winfrey split these into six quantum levels from low to high. Mathematically, one can show that a low modal frequency curve yields a flatter survivor curve while a high modal frequency curve produces a steeper survivor curve.[3] The resultant curves are now identified by a letter and a digit, the former designating the Left (L), Symmetrical (S) or Right (R) and the latter, the relative height of the mode (1 to 6). For example, the highest least dispersed Right Modal curve would be termed and "R-6". Subsequent enchancements allowed intermittent curves for higher resolution (eg. R-5.5).

Knowing the curve shape, one could also calculate the probable life curve of the remaining assets. By summing the area under the curve beyond a certain age and adding that value to its current age, a probable life curve is produced. It is interesting to note that as the earlier retirements occur, the probable life of the remaining assets continually rises to the point of the final retirement, usually exceeding 2 times (200 per cent) the average service life and occasionally exceeding 4.5 times (450 percent) the average service life.

During the procedure, it is not necessary to know which assets will survive. It is enough to know the number surviving.

Mathematically, one can translate the curve into a series of assets of varying lives and follow the ELG procedure outlined above.

4.5.1 Effect of Changes in Curve Parameters

While ELG, using survivor curves, is theoretically superior to the Vintage Group Method, it is still fundamentally a straight-line method, subject to the limitations of that class of calculations.

Mortality curves play a major role in the traditional calculation of depreciation expense. This section isolates the effects of variation in two life characteristics,

1) degree of symmetry (left, symmetrical, right), and,
2) degree of peakedness,

on the discrepancy between the two methods. Several runs were made with various curve shapes to determine a typical pattern for each of the two main variables.

1) Degree of Symmetry

Four Iowa type curves are tested, at an average service life of 30 years:

a) L1,
b) S1,
c) R1, and

d) Rectangular.

As the shape of the retirement curve changes, the mix of expected lives follows a different pattern, changing the timing of depreciation expenses.

However, the pattern of <u>discrepancy</u> between depreciation methods is not necessarily the same as the pattern of depreciation expense itself. The rectangular survivor curve (simultaneous retirement of all assets) which has the "best-behaved" Straight Line curve, actually causes the greatest overall distortion in prices between the Straight Line Method and the FASFM. This would be expected since the rectangular retirement curve has none of the compensating errors inherent in the other "distributed" retirement curves.

Although the other three curve shapes have grossly different depreciation expense curves (see Figure 4.5.6), they all generally follow the same shape as their respective FASFM Depreciation curves. The distortion in price caused by the existence of one versus another survivor curve shape is therefore very minimal and typically much lower than the discrepancy existent in an "integrated asset" with a rectangular curve shape (see Figure 4.5.7). Unfortunately, utility industries do have a large proportion of assets of the "integrated" type.

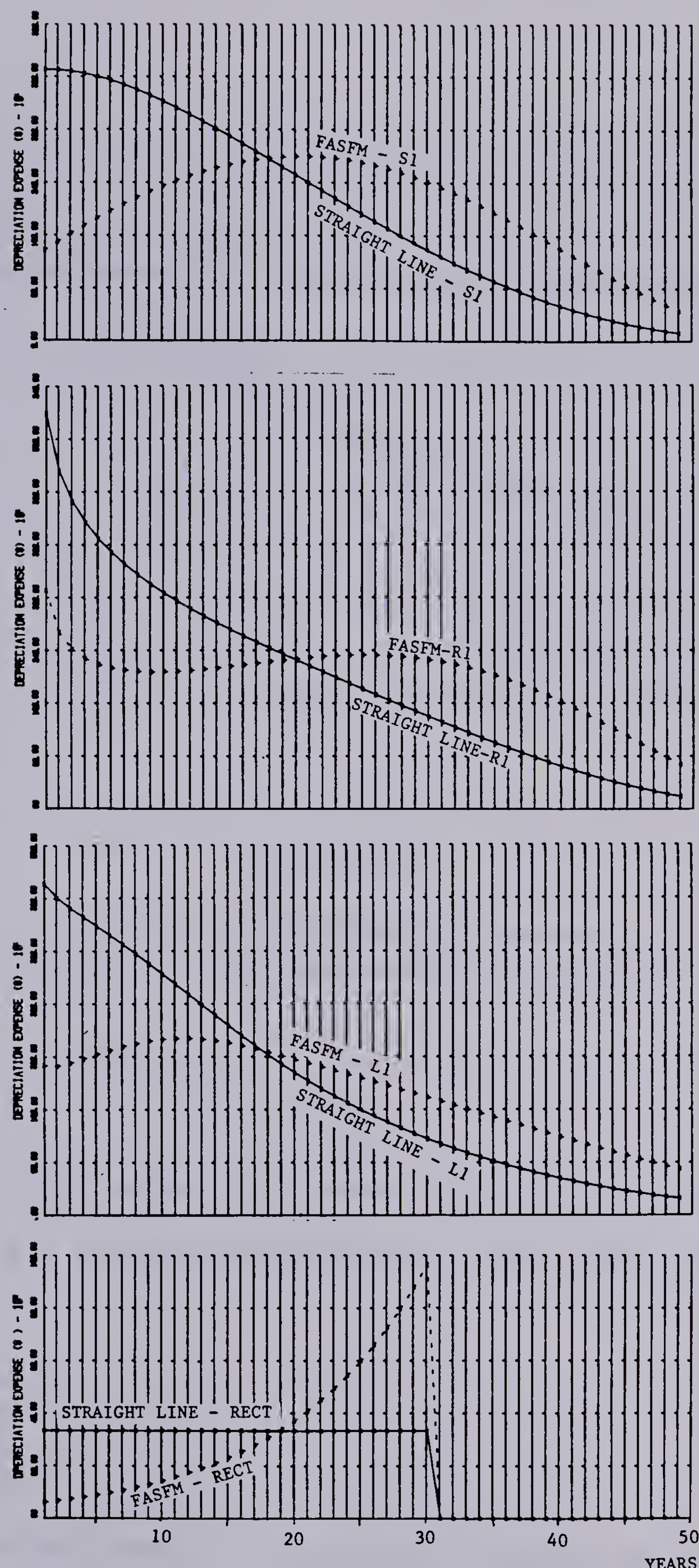


Figure 4.5.6

Comparison of Depreciation Expense
For Curve Shapes of Varying Degree of Symmetry

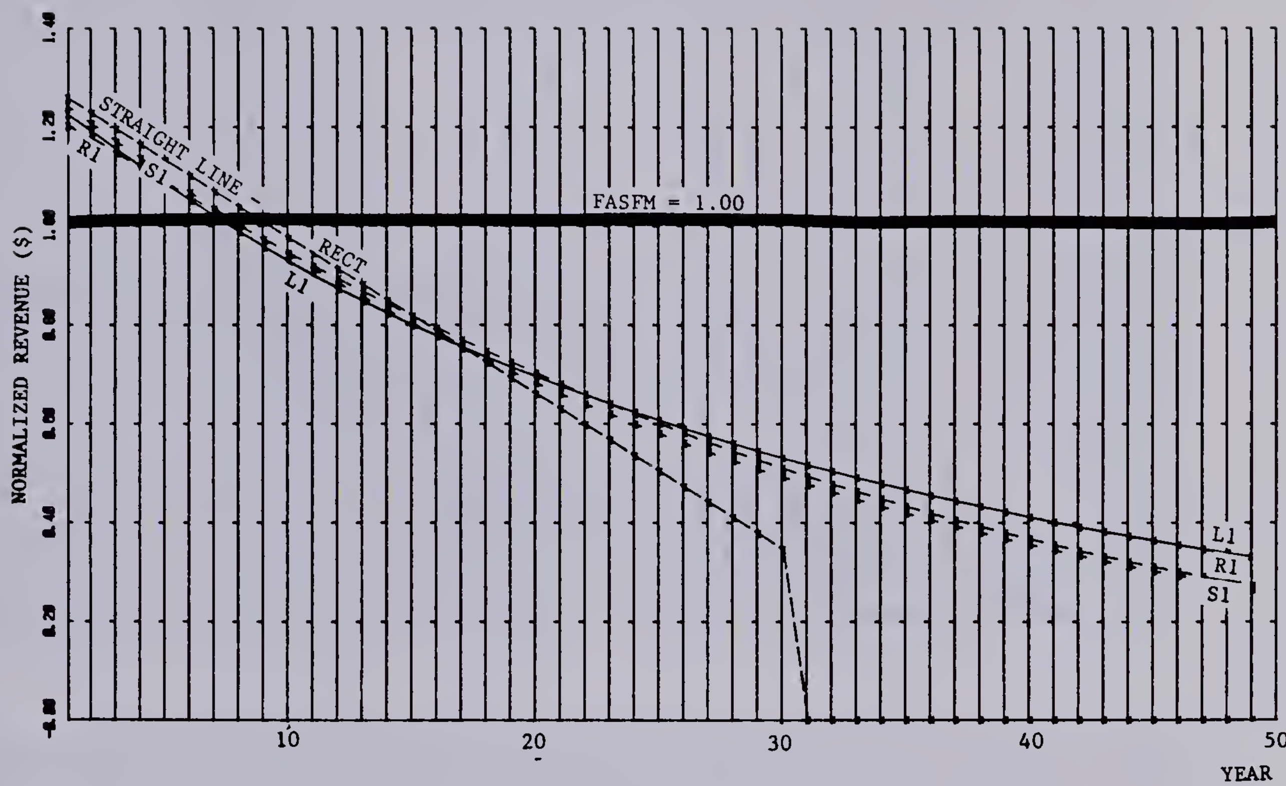


Figure 4.5.7

Comparison of Normalized Revenue
For Curve of Varying Degrees of Symmetry

2) Degree of Peakedness

Again, four curves are tested, using the symmetrical curve series and varying the peakedness. The curves tested are:

a) S-0.5,
b) S1,
c) S3, and
d) S6.

For various levels of peakedness, unlike the previous curve shapes, the discrepancy between the Straight Line method and the FASFM varies dramatically and consistently.

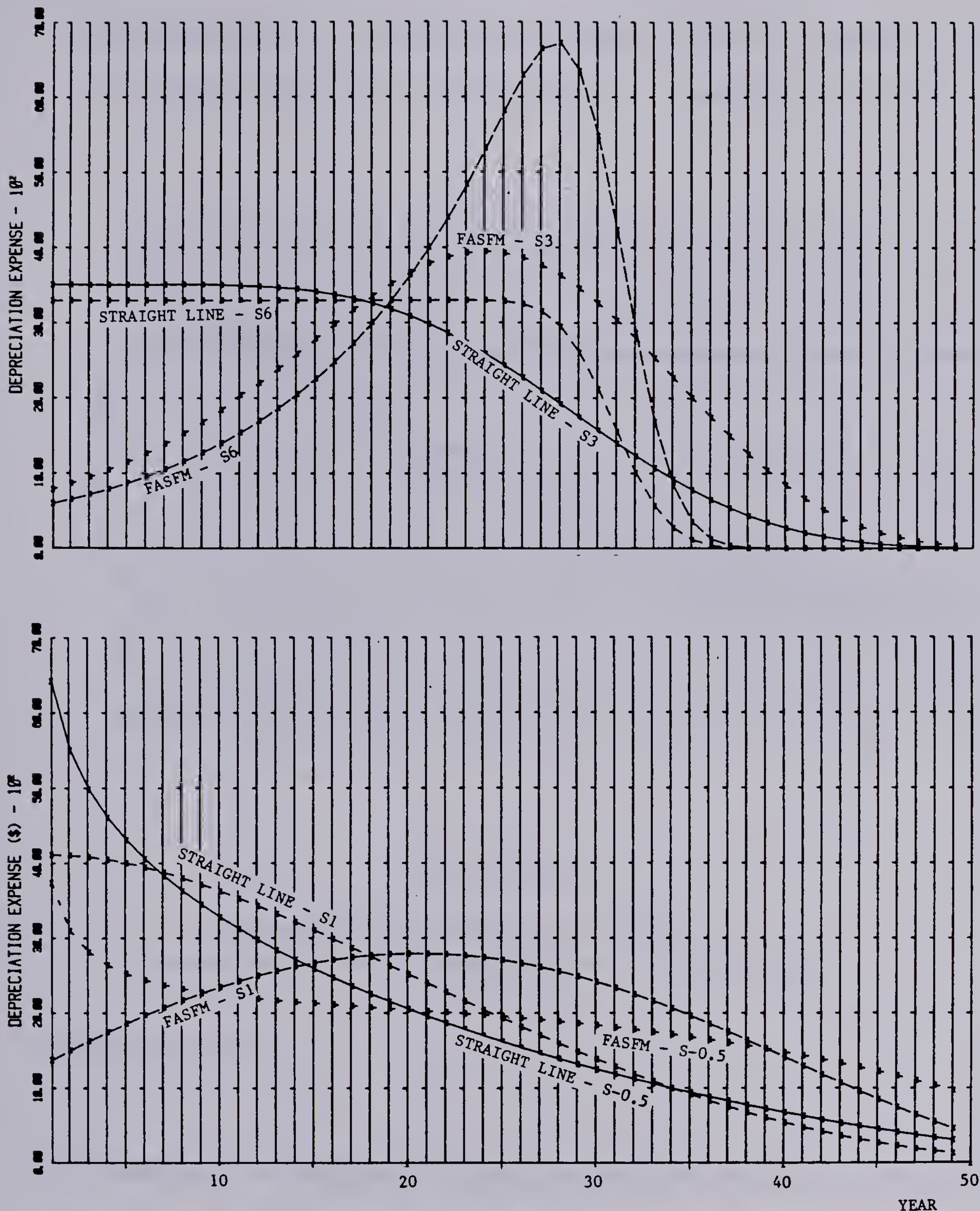


Figure 4.5.8

Comparison of Depreciation Expense
For Curve Shapes of Varying Degrees of Peakedness

The S6 pattern (see Appendix B) is so peaked that retirements only occur during 70% and 130% of average service life compared to 0% to 200% for the S1 pattern. This clustering of retirements removes most of the opportunity for cancelling

discrepancies in depreciation expense and also reflects itself in higher total price discrepancies. (see Figure 4.5.9).

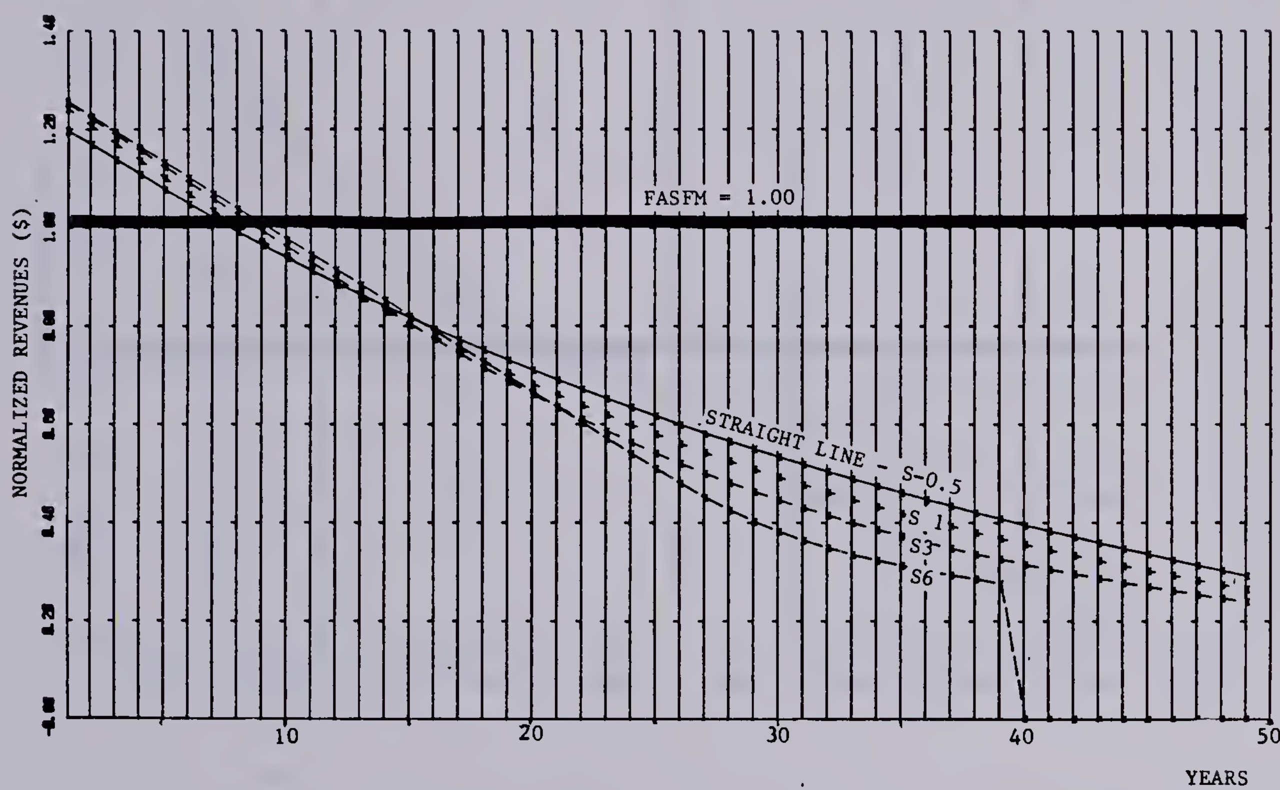


Figure 4.5.9

Comparison of Normalized Revenue for
Curve Shapes of Varying Degrees of Peakedness

4.6 INFLATION RATE

The FASFM can be modified slightly to adjust prices in each year to obtain Graham's[1] ideal price which equates buying power (real dollars) in each year rather than money dollars. By multiplying each customer year by its appropriate inflation index, a "real" price can be determined which can be reinflated to calculate each year's price. This process further lowers the depreciation charged to earlier years and raises depreciation in subsequent years.

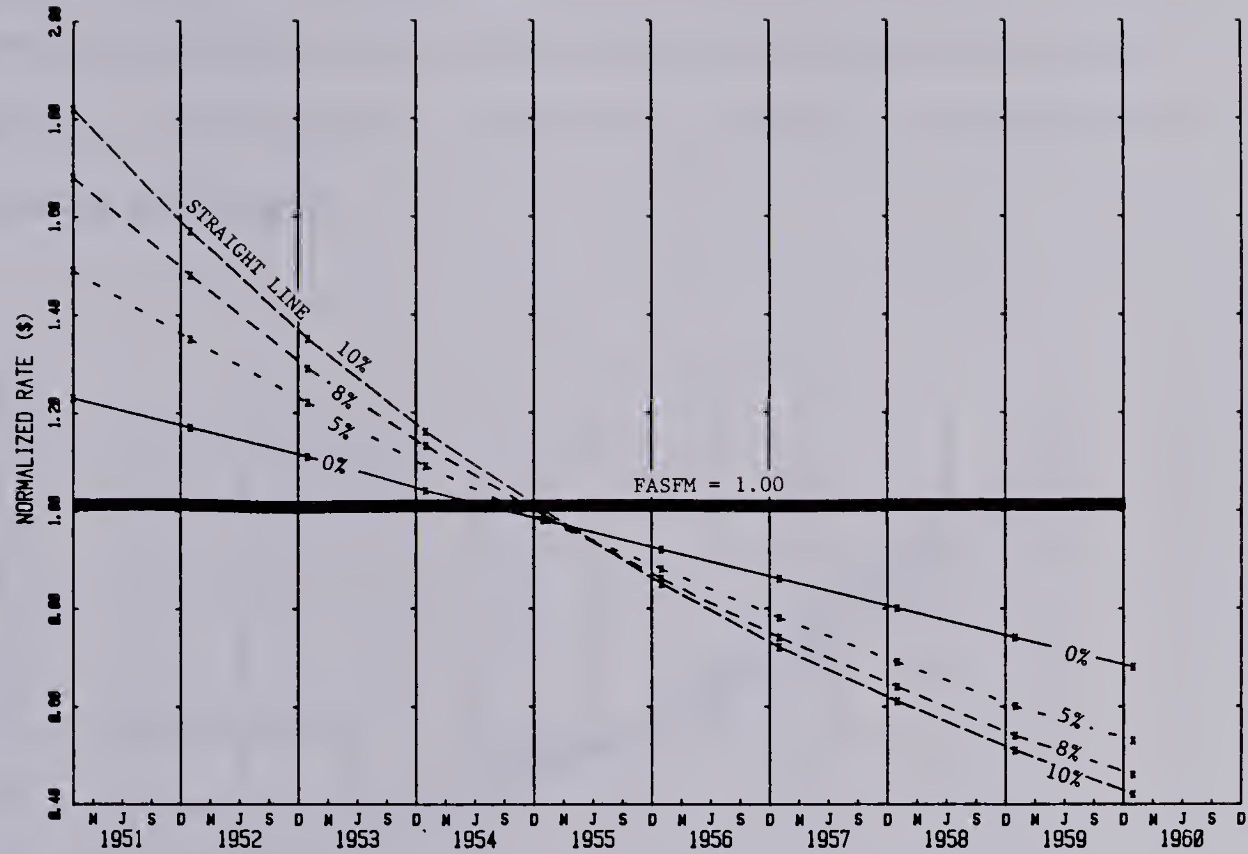


Figure 4.6.1

Comparison of Normalized Revenues for Various Levels of Inflation

At zero inflation, the discrepancies between the two methods are identical to those in the non-inflation example. As inflation increases, so do discrepancies. Net income in earlier years is more negative. In early years, prices are lower for the FASFM method, causing a wider discrepancy with the unchanged Straight Line Method rates.

In the real world, as inflation increases, there is a pressure to go to longer economic intervals on plant sizing, causing even larger discrepancies between methods.

While the effects of inflation are very real and the technique for

adjusting the FASFM is theoretically correct, it will not be used in the next chapters since the current accounting practice in a regulatory environment tends not to accept the price level accounting philosophy.

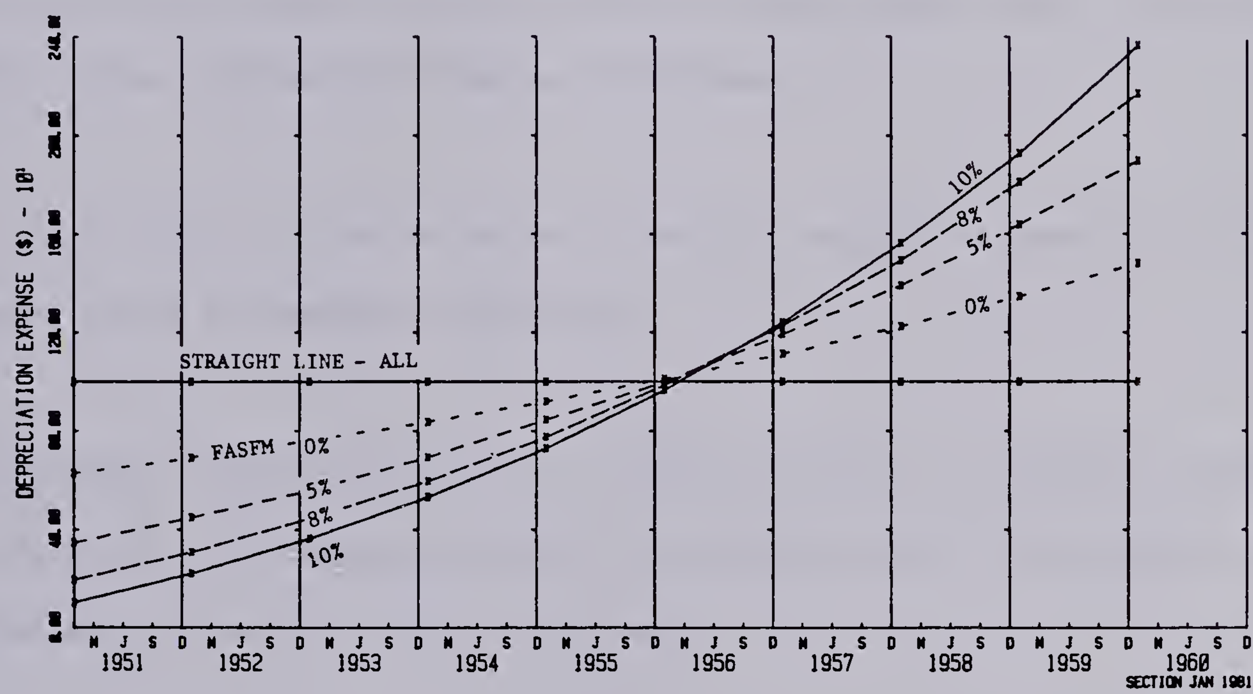


Figure 4.6.2

Comparison of Depreciation Expense
For Various Levels of Inflation

SUMMARY

Six major variables were introduced to show the various determinants of the degree of discrepancy between the two depreciation methods. Three of these variables, called fundamental factors, 1) interest rate, 2) service life and 3) fill profile, affect the "discrepancy cycle" over the life of a single asset. In all three cases, the cumulative depreciation expense finally recovers the full value of the asset in both methods but in a different pattern for each.

The next two variables, growth pattern and mortality curve shape, tend to mitigate the effects of these discrepancies by mixing several assets at various stages of their discrepancy cycle together, causing some cancelling of errors. While changes in curve symmetry do not materially affect the discrepancy pattern between methods, the peakedness of the survivor curve has a great impact, with the more peaked (less dispersed) retirement curves showing the highest discrepancy.

Finally, the effects of inflation were briefly presented showing how the FASFM model could accommodate inflation.

The next chapter implicitly mixes all these variables by actually running each vintage of each account through the computer model and summing the key parameters across the entire asset base.

1. Adapted from R.N. Maher "Let's Take Some of the Guesswork Out of Depreciation", Telephone Engineer and Management, p. 30, September 15, 1975.

2. R.N. Maher, P. 30.

3. Iowa State University. Proceedings of the Fifteenth Annual Conference on Public Utility Valuation and Rate Making Process (Ames: Iowa State University Press, 1976).p. 199.

CHAPTER FIVE

THE EMPIRICAL MODEL

5.0 GENERAL

The last Chapter studied six parameters independently which affect the discrepancy between depreciation methods. This chapter considers these parameters simultaneously to see how a typical utility company under conditions of high growth and inflation, is affected by choice of depreciation technique.

The method of analysis is straight foreward, albeit, very ponderous. The entire collection of assets is split into groups which are homogeneous with respect to vintage, account code, location, and life. Each group is entered into a computer model which calculates a series of depreciation expenses and other related data first for the traditional Straight Line Method and then the Fill Adjusted Sinking Fund Method.

The model slots this computer data series from each asset group into the proper band of years and finally sums the data across all groups.

The first section of this chapter will outline the sources of raw data and show some of the operations that must be performed to arrive at homogeneous asset groups from this data. The second section explains how the fill profile of the assets is developed for each class of asset. The third section explains some of the

limitations and simplifying assumptions of the study. Finally, the results of the composite run are presented and interpreted with comments on how this might affect regulatory aspects of depreciation.

5.1 COMPILING THE RAW DATA

5.1.1 Categories of Assets

If there is one unifying characteristic of telephone data, it is its diversity. Even with a small telco like the subject company, 'edmonton telephones', which has only the most basic toll equipment and a very limited selection of data offerings, there are no less than 60 separate assets accounts. (See Appendix 1). Each of these encompasses of a wide variety of differing sub products. For convenience, most can be grouped into three broad classes. (See Figure 5.1)

1) central office equipment,
2) outside plant, and
3) station apparatus.

1) Central Office Equipment

This category of assets includes all switching equipment, associated internal wiring, distribution frames, and testing facilities. It can be further split into the different technologies which have developed since the basic telephone was invented. The switching systems are conveniently grouped into four sub-categories:

a) Step-by-step (SXS)

Step-by-step equipment is named for the manner in which the switching progresses in steps through a complex electromechanical maze, additional switching being added as subsequent numbers are dialed. This technology, while still constituting a large portion of 'edmonton telephones' central offices, is obsolete and is scheduled for a fairly rapid conversion over the next decade. Its mechanical operation introduces an amount of noise unfavourable to high rates of data transmission, and is subject to extremely high maintenance costs.

b) Cross-Bar (X-BAR)

This intermediate technology, still predominantly electromechanical, was the first step toward "Common Control", the alternative to step-by-step, in which the number to be called is completely entered into a storage device, after which a path through the office is established by a central device, operating several switches simultaneously to set up a call.

This technology enjoyed only a brief period of supremacy until it was overtaken by the next advance. X-BAR will be the next technology to be replaced.

c) Stored Program

This type of office, while still using a miniturized version of the Cross-Bar switch, was a major advance in that its switch logic was defined by software rather than "hard-wired" like the Cross-bar switch. This design made the machine "forward compatible" to subsequent updates and to enhanced service features, theoretically deferring its functional obsolescence.

However, since it still has many moving parts at critical locations, it requires some personnel for expensive scheduled preventive maintenance to ensure continued good service. The mechanical cross-points used by the system also limit the type of information it can adequately switch. The typical stored program office at 'edmonton telephones' is the Northern Electric supplied "SP-1". While this technology will still cost effectively perform most existing voice and medium speed data, it is incapable of providing switched video or other high bit rate information.

d) Electronic

The electronic office, which switches messages through solid state cross points, has no moving parts in the direct message path. It ushered in the age of the unmanned office and the remote field switch. This mode of switching realizes a quantum jump in the range of speed and quality of

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

information it can switch. It behaves no differently whether carrying voice, video or data information, at high or low speed, and could therefore accommodate virtually any future application for switching information. Because of its solid state design, maintenance is minimal.

The trend in Central Office technology is towards an even more integrated, compatible, reliable device for all forms of information.

The building, wiring and rack work associated with all the above technologies are kept in separate accounts.

2) Outside Plant

This category of assets includes all transmission media and supporting structures between central offices and out to terminal locations. Historical cost data on cables is separated by vintage, type of sheath, type of insulation, gauge and pair size. Since varying exposure to the elements and to mechanical abuse will affect the longevity of cables, they are also split into three accounts, designating the type of structure supporting them.

a) Aerial Cable

Aerial cable, like the original aerial wire which it has essentially replaced, is supported on poles. All the

support structure and associated hardware is accumulated in a separate account. Besides its increased exposure to the elements, aerial cable is also subject to functional obsolence as communities request its replacement by the more aesthetic underground and buried cables.

b) Underground Cable

Underground cable is differentiated from buried cable by virtue of being placed in conduit rather than being directly buried in an unprotected state. Its support structures, manholes and conduit, are kept in a separate account.

c) Buried Cable

The specially sheathed and insulated cable is directly buried without any supporting structure. In the City, it is usually trenched in but may be plowed in.

All Cable is categorized into two broad functional categories,

1) feeder, and
2) distribution.

The feeder cables are used to connect central offices together and to extend the central offices out to main feeder areas. From there, the City is split into small self contained areas, served by the distribution cable.

In the feeder cable, virtually all pairs are available to anyone in that feeder area. However, in the distribution system, a particular cable pair is dedicated either to a single subscriber or to a small number of subscribers. Typically, underground cable is used for feeder applications while aerial and buried are predominantly used for distribution.

Besides traditional cables of paired wires, Edmonton has started to accumulate some investment in other mediums of transmission, including various types of coaxial cable and fiber optics cables. These cables are less prone to functional obsolescence as the industry contemplates the "Single Integrated Network (SIN)" concept of providing all existing voice services, video, security and control data services on one integrated medium, along with all the new customer demands for a proliferation of new products (teleshopping, pay television and computers). In fact, these new concepts threaten to shortern the lives of paired cables to the point where a notable Telecommunications Industry theorist, G. Thompson of Bell Northern Research, suggests we will soon be "mining" copper out of the duct systems.

3) Station Apparatus

At the end of each cable or fibre, the subscriber has a vast choice of products with which to inject his information onto the network. Where once there were just single-line telephone sets, the choice has expanded through key systems and PABX's to a

virtually limitless array of data terminals of all types. Separate accounts have developed over the years to continually refine this equipment into groups of life-homogeneous assets. The Station Apparatus account now includes items which are not even hooked up to the network such as radiotelephones, pagers, apartment enterphones and wired music.

A small portion of telephone assets are placed into special accounts including tools, vehicles, computers, office equipment and furniture.

5.1.2 Treatment of Accounts

This wide range of assets requires extreme flexibility in treatment with respect to depreciation. Land, except for minor improvements, is not depreciated. Some assets are depreciated individually and others are lumped together. For major assets, there are two broad categories of treatment:

1) Integrated Properties

Large assets which are generally retired as a single unit rather than in small portions, are grouped into a category called "Integrated Properties".

Although they may be retired simultaneously, all parts of an integrated property may not have been constructed in the same year. The best example, and the major component of this

category, is Central Office Equipment. A typical Central Office, the Churchill Square Wire Centre, still has working assets which were placed as early as 1945 and some placed as late as this year. When the site is retired in 1985, the entire unit will be removed.

For this type of asset, the entire account code or sometimes, one location in the account code, is assigned an average year of final retirement (AYFR). Each vintage within that property is retired over its respective remaining time span.

2) Mass Properties

The other type of asset, "mass properties", consists of a very large number of similar assets, each one of which could be retired independently (e.g. telephone poles). Since it would be impractical to have a record for each individual asset, they are summarized by vintage. Rather than write off a particular vintage over the same time span, the company uses the actuarial Equal Life Group (ELG) method described in Chapter Four, to assign a probability distribution of lives to each vintage and depreciate each separately.

5.1.3 Process

The collection of data for this study was greatly facilitated by the tightly structured files maintained by the depreciation engineer. Each account code is filed sequentially, listing each vintage and

the amount of plant placed in that year, called the "Gross Additions". For the integrated properties, which were generally split by location, the vintage and gross additions were recorded. Since all assets in a particular location would have the same average year of final retirement, the expected life was determined by simple subtraction of the vintage.

In the same file, the expected salvage value, determined by a series of special studies by the depreciation engineer, was also recorded for the account as a percentage of historical cost.

For mass assets, each account file contained the survivor curve shape and the account's expected average service life, which had also been determined by special study. By inputting this data to the author's program, the computer calculated Equal Life Groups for input to the major module, which calculated the two comparative depreciation expenses, Straight Line and Fill Adjusted Sinking Fund Method.

Even before being split into the various Equal Life Groups, (up to 4.5 times as many groups as the average service life), there were nearly 1400 different groups of assets. (See Appendix 2). The computer had to calculate approximately 30,000 series of depreciation streams.

After this data was gathered, the assets were divided into two groups, those which would be expected to start full and remain that way, and those which would be expected to fill up slowly over time.

The former would consist of all station apparatus (telephones, pagers, PABX's). The latter would include all Central Offices and most non-dedicated outside plant. Coaxial cable, by contrast, was assumed to be placed only for a particular customer and would therefore be full over its entire life.

Choosing the fill for the second category of assets is explained in more detail in the next section.

5.2 DETERMINING FILL PROFILES

5.2.1 Mechanisms of Fill

Many factors influence the fill of utility assets. While running an asset at below its capacity is sometimes caused by over-estimating market demand, much of the extra capacity in the telephone system is actually designed in by engineers. The purpose of over-building could be summarized into three main categories:

1) Economic Intervals

The cost of supplying many assets in the telephone industry is not proportional to the units of service provided. For example, each time an addition is planned for a Central Office, a great amount of engineering must be done, regardless of the size of the addition. Since this fixed cost remains essentially at one level regardless of the size of the addition, the engineer would save money by adding extra capacity, so that its fixed cost

component would not have to be incurred again for another addition. This savings must be weighed against the carrying cost of additional idle capacity.

Several models exist for choosing the optimal size of capital extension from the very simplistic "economic interval" model proposed in the Engineering Economy manual of the Bell Telephone system, to more complex dynamic and integer programming models.

The Bell Telephone formula, which assumes a constant and continuing growth, is as follows:

$$t = \sqrt{\frac{2Co}{c\left(\frac{a}{p}\right)_n^i}}$$

Where:
- t = Economic interval
- Co = "Getting started" costs
- c = Incremental capital costs to satisfy one year's growth
- $\left(\frac{a}{p}\right)_n^i$ = Annuity factor from a present worth for "n" years at "i" percent interest

Other techniques have also been developed by Bell Telephones[1], which relax the constant growth assumption, most notably, RAPS, Route Analysis Planning System.

These models determine, from the fixed and variable cost components of various configurations, the most economical size of plant for a given expectation of growth, interest rate, and inflation rate. The higher the inflation rate and the lower the interest rate, the larger a unit of capacity is added.

Similarly, the larger the "start-up" cost compared to the unit

variable costs, the larger the unit will be chosen. Also, the greater the yearly growth, the larger will be the size of each addition. Applying the Bell Telephones model which is used by 'edmonton telephones', some typical economic intervals for certain types of assets would be as shown in Table 5.1.

Table 5.1

Typical Economic Intervals
Selected Telephone Assets

TYPE	ECONOMIC INTERVAL (YEARS)
Buried Cable - Feeder	5 *
Conduit	55
Central Office - Electronic	2

* Source: The City of Edmonton

From these economic intervals, one can infer the way in which any asset will fill over its life. If actual past fill data were available, this could be used to infer future fill patterns.

2) Marketing Considerations

The telephone company can achieve a marketing advantage from supplying excess capacity by being able to provide service within a very short time period. This "service interval" is a key indicator of quality of service. Since regulators award the behavior of keeping that standard high, companies are motivated to spend money to ensure it remains so. Since it might take several months to engineer, furnish and install a cable pair to

a subscriber, the telephone company runs is cables at a design fill below actual capacity. Once this capacity is exceeded (about 85% for cable) the process of relieving that cable with additional plant is initiated. Therefore, at any time, there is every chance that any particular cable is not fully utilized. The ultimate example of this is "Dedicated Plant". Using a fairly new design methodology call "Serving Area Concept" (SAC), the serving area is divided into feeders distribution areas, joined at a "Jumper Wire Interface (JWI)", a cross-connect point between feeder and distribution cable. The feeder is designed according to the economic interval concept.

By contrast, the distribution is designed to ultimate capacity and each customer has two dedicated pairs, from his home back to the JWI. In executive areas, this design parameter is raised to three dedicated pairs per household. The further downstream from the central office, the less an engineer can take advantage of "fill engineering".

3) Quantized Materials

The manufacturers of telephone equipment, to keep tooling costs to a minimum, provide only a limited range of different pair sizes in cables. The engineer, in virtually all cases, must choose a cable either bigger or smaller than the designed fill. He will usually choose the bigger cable. This again tends to create a situation where an asset is not full from its first day in service.

5.2.2 Approximating Fill Profiles by Asset Type

Because the fill profile may have profound affects on the depreciation rates using FASFM, it is important to accurately reflect the pattern of fill of assets. However, this data is not readily available. The telephone company collects very limited longitudinal fill data by individual asset. Most fill data is used for day-to-day administration of service. One example of this data is the "Available Spares Report", which lists, by Wire Centre, the number of telephone numbers currently not assigned to any customer. Another example is the "Rack Sheet" which shows which feeder cables pairs are available. As administrative inventory reports, they are not designed to show the progress of fill of a single unit of asset, but rather to show a snapshot of a collection of assets.

Fill Data for engineering is largely collected on a very aggregate level (wire centre area or feeder route area), usually on the basis of population or some other convenient data series, on an as required basis. Often, engineering rules of thumb preclude the need for any fill data whatsoever.

Therefore, for the purposes of demonstrating the discrepancy between Straight Line depreciation and FASFM, it must suffice to determine typical fills rather than use exact empirical fills.

Also, since the computer model will be handling thousands of data elements, a certain amount of simplification of fill profiles must

be done in this demonstration to keep the analysis within the cost constraints. For all assets, the fill profile will be approximated by a curve consisting of two linear components (See Figure 5.1).

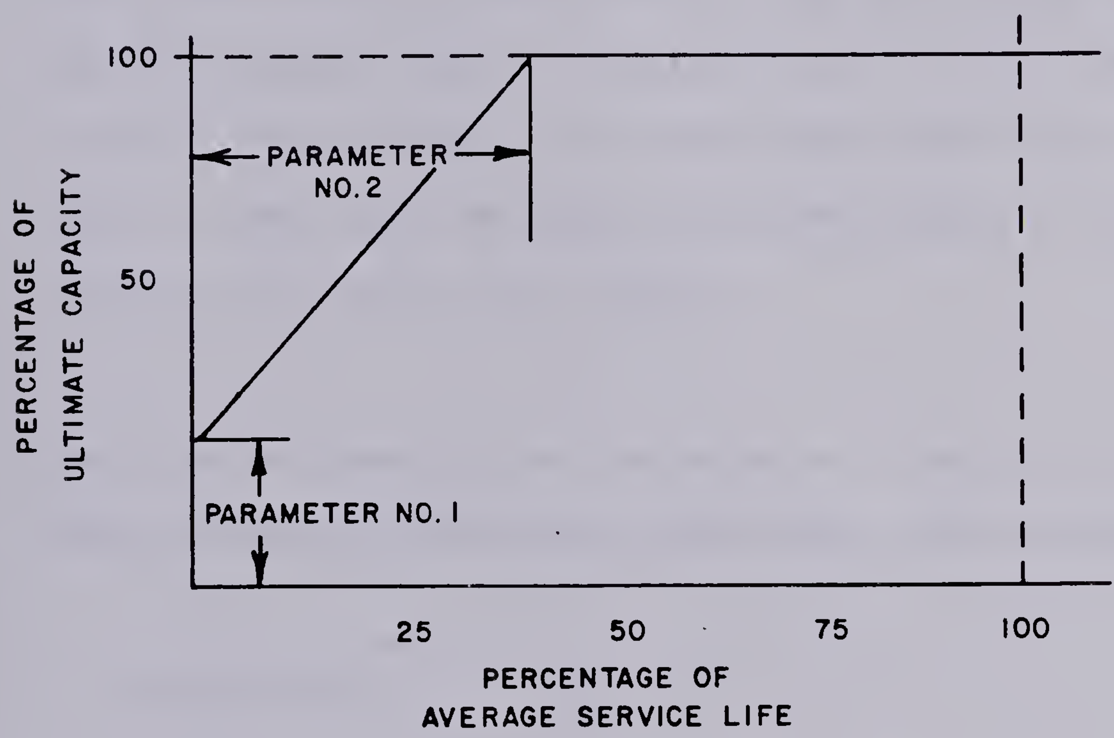


Figure 5.1

Generalized Fill Profile

The curve is defined by two parameters. Parameter #1 shows the starting fill, expressed as a percentage of ultimate fill. The ultimate fill need not reach physical capacity, as is the case with many assets.

Parameter #2, describes the percentage of service life at which the asset is expected to reach its ultimate capacity.

The values of these two parameters were chosen for each account code in consultation with design engineers for the respective assets.

For mass assets, the fill profile for each individual Equal Life Group of a particular vintage will be different, even though the shape parameters are the same. For example, if Parameter #1 and Parameter #2 had respective values of 20% and 50%, for the ten year Equal Life Group, the asset would be 20% full in year one and would gain 20% each year until it was completely full at 5 years or 50% of its life. By contrast, the 18 year Equal Life Group would be 20% full the first year and gain 10% per year until it was completely full by the 9th year of the analysis.

Since Station Apparatus is considered to be full at all times, only fills for central office and outside plant need to be estimated.

1) Central Office

Each technology requires a different analysis;

a) Step-by-step

All Central Office equipment is engineered using the Economic Interval method with some tempering for engineering judgement. As explained in appendix F, the length of the economic interval between placements is determined by four main factors, the growth rate of demand, the interest rate, and mostly, by the relative costs of startup and incremental cost. In step-by-step equipment, the cost of an addition includes the cost of engineering, rearrangement of existing

plant and significant racking and cabling costs. Partly because of this high startup cost and partly due to overly optimistic forecasts, step-by-step offices were usually added at approximately five-year intervals. Therefore, using average service life of approximately 25 years, it was assumed the asset would be 20% full during the first year (1/5 of 5 year growth to fill) and would be full by 20% (5 years ÷ 25 years) of average service life.

b) Cross-bar

Using similar methods and typical past placements of an office every 2 years on an average service life of 20 years, (although a shorter placement frequency has been required in this high growth situation). Year 1 fill was set at 50% of ultimate growth and was expected to be full at 10% of average service life, or 2 years.

c) SP-1

Similarly, for SP-1 with a 2 year fill and a expected 40 year life, the parameters were set at 50% and 5%. For most Electronic offices, the interval could theoretically shrink to an "as required" basis. Because of the existence of the large one time costs of the Central Processing Unit, the analysis actually must be split between CPU and the lines themselves.

The structures supporting central offices are generally designed for a much larger time span. Assuming a 20 year fill period on a 40 year life, the parameters are 5% and 50%.

2) Outside Plant

Outside plant capacity is calculated differently for different applications, depending on whether the cable is used as a feeder or a distribution facility.

a) Feeder

Feeder cable is primarily restricted by design guidelines to underground cable (Account 5C). Like the Central Offices it is sized by economic interval techniques. Typically, a feeder cable is expected to fill to capacity in 5-7 years. The starting year would therefore take 20% of growth. Assuming a 33 year life, the cable would be full at slightly less than 20% of its average service life.

Conduit is also sized by the economic interval method. In the City, because of the high cost of installing conduit, especially in developed areas, the ratio of startup costs to incremental cost is abnormally high (25:1 compared to less than 1:1 for central office), making the theoretical economic interval for normal growth areas exceed its average service life. Therefore, the proper strategy is actually to

design conduit to its ultimate capacity. Assuming a 55 year life and a one duct fill (out of an average duct size of 8 ducts), in the first year, the parameters are set at 13% and 99% respectively.

b) Distribution

Distribution cable is sized by ultimate capacity, usually two pairs per household (3 for executive areas). Typically, the growth is slow for 1 - 2 years, rapid during years 2 - 4 then slowly reaching saturation by year 10 as alternate housing "fills in" the area. During sagging economic conditions multi-family housing may actually occur during the rapid growth phase.

Although Aerial Cable (Account 2C), was once prevalent, current subdivision design is predominantly buried cable (Account 65C).

The three stage growth pattern cannot be accomodated by the computer program. Therefore, a compromise was reached by assuming a higher initial fill and lower years to reach saturation, yielding parameters of 20% first year fill and complete fill by 20% of life (See Figure 5.2).

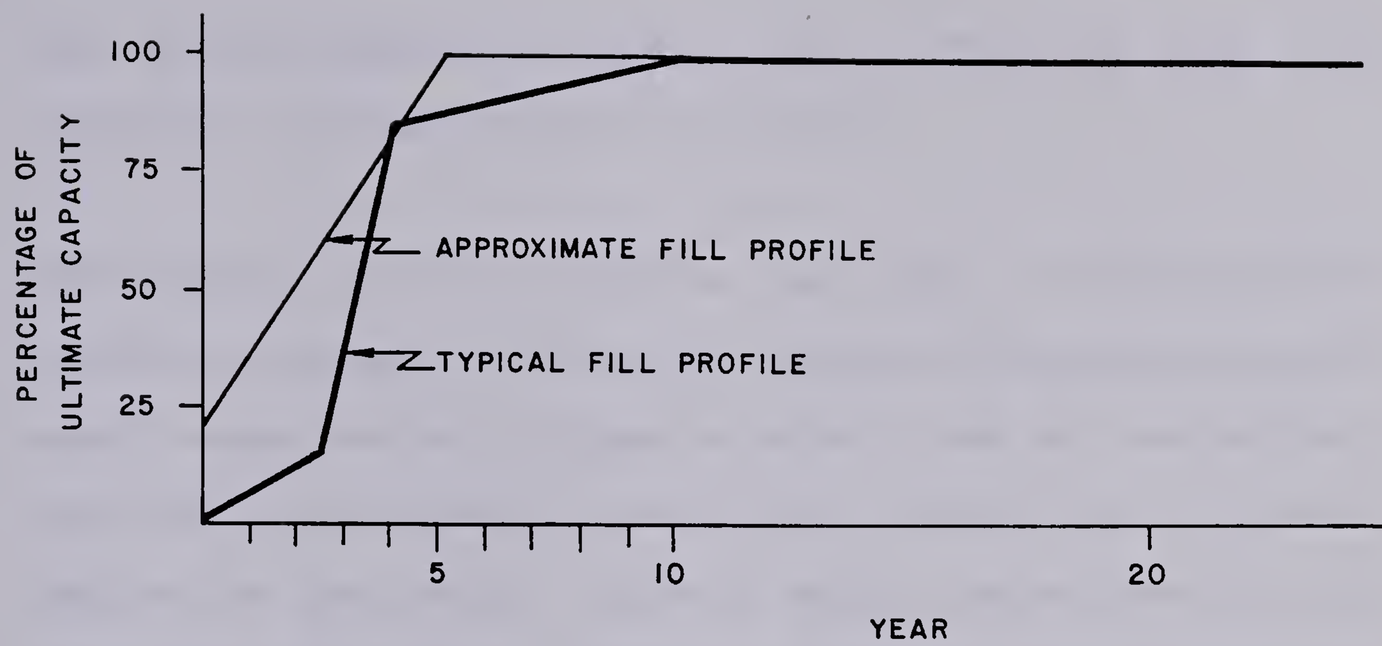


Figure 5.2

Typical and Approximate Fill Profiles
For Distribution Cable

5.3 LIMITATIONS

As with any complex study, this analysis is based on many simplifying assumptions and limitations. To more adequately evaluate the claims presented in this paper, a list of these limitations is presented below, with a brief explanation of their possible impact.

5.3.2 Half-year Convention Ignored

In the Telecommunications Industry, as in most utilities, the historical cost of an asset is not allowed to be included in the rate base until it is put into active service, being held in a "Plant Under Contruction" account in the interim. Since the physical number of new assets is too large to allow the company to practically keep track of the actual date a particular asset was put

into service, depreciation is calculated as though all asset were activated at the exact midpoint of the year.

The computer model was simplified such that it calculated the depreciation expense, not using the midpoint, but assuming the asset earned revenue for the full year in which it was put into service. Gross Additions for 1980 were $50,773,513, or 13% of the total Gross Additions of $386,109,261. With an overall depreciation rate of 6.1%, this would cause an error of $1,523,205 (ie. $50,773,513 x .06/2).

While this treatment is identical for the Straight Line Method and the Fill Adjusted Sinking Fund Method, it nonetheless biases the result of the study slightly. Since the FASFM Method results in substantial deferrals of depreciation relative to the Straight Line Method, giving first year assets full influence in their first year slightly overstates the overall discrepancy between rates.

5.3.3 Slope of Integrated Assets

Although the curve shape of integrated assets is considered to be rectangular (no retirements until final retirements), in fact, small interim retirements do occur over the life of some assets, typically less than 1%. Because the error introduced by this simplification was not expected to be material, the computer model does not adjust for it. While the modifications would be very simple, the running time of the model would increase dramatically.

5.3.4 Step-by-step Replacement Program

Only since the advent of the electronic switch was serious consideration given to the replacement of the generally reliable Step-By Step Central Office equipment. Until that time, studies done by several telcos showed that the savings in maintenance costs were not enough to overcome the tremendous capital costs of replacement.

However, with inflation on electronic gear being largely cancelled by increased productivity of design and manufacturing techniqes, it is now economically feasible to replace the old electro-mechanical devices. 'edmonton telephones' has just recently decided to undertake an aggressive replacement schedule, mitigated more by Capital budget constraints than economics.

Therefore, there is a major discontinuity in the expected remaining life of these assets. While the depreciation rates determined by this change in policy are correct, they do cause abnormally short lives for these types of assets. Since the shorter the life of the asset, the less discrepancy there is between methods, this occurrence tends to mitigate the discrepancies one would expect without this anomaly.

5.3.5 Changes to Station Apparatus Life

Similarly, because of the impact of interconnection, allowing competition in the non-network sector of the Telecommunications

industry, the expected life of all Station Apparatus (128C) is expected to diminish abruptly in the next few years. Rather than immediately change to a lower expected life, 'edmonton telephones' has decided to mitigate this effect by progressively lowering its service life over a period of years from an original ten year estimate to one of five years.

While there is no theoretical mathematical basis for this procedure, it will provide a more smooth transition than immediately changing to a shorter life expectancy. However, because the 1981 depreciation will vary significantly from 1980, the ability of this model to predict future depreciation trends is somewhat hampered.

5.3.6 Accounting Inadequacies

Prior to 1969, maintaining accurate property records for 'edmonton telephones' assets was not given a high priority. Therefore, data before that time, esspecially in mass accounts, had to be reconstructed by a mammoth inventory of assets in that year. In some accounts, most notably Station Apparatus, significant discrepancies were found between theoretical asset values and the newly evaluated inventory of existing assets. Some necessarily arbitrary adjustments were made to these accounts. Fortunately, because of inflation, these assets had a relatively small value and therefore, do not exert excessive influence over the analysis.

A more profound effect could be expected from another accounting problem. Currently when certain assets are removed from service,

(notably Underground Cable (5C)) and subsequently reinstalled, they are recapitalized on the way back in, at an average cost even though they have not been retired from the account on the way out. The depreciation engineer has compensated for this by adjusting each vintage downwards by its expected reuse amount and depreciating each vintage over its service life (as opposed to its location life which includes only its time at its current location). By subtracting the total expected current year retirements, as calculated using service life, a target net increase in reserves is calculated. To this target amount is added this year's non-reused retirements as calculated using location life. This yields a depreciation expense which will change the depreciation reserve, after being adjusted for current retirements, exactly as targeted (See Table 5.2).

Table 5.2

Adjustment Procedure for Reused
Underground Cable (1980)
'edmonton telephones'

DESCRIPTION		$
Expected Depreciation Expense (Service Life)		1,673,817
Expected Current Year Retirements from All Vintages (Service Life)		357,384
Target Change in Depreciation Reserve		1,316,433
Expected Current Year Retirements from all Vintages (Location Life)	516,046	
Less Expected Reuse (516,046 x .32%)	165,135	
Plus expected net Retirements		350,911
Required Depreciation Expense		1,667,344

* Source: City of Edmonton

Since this adjustment has no sound theoretical basis, the original

gross additions were used in the computer model at their service life. This will tend to overstate the asset. Depending on its relative discrepancy to the other assets, it may bias results in either direction.

5.3.7 No Future Estimates

No gross additions have been inputted for vintages subsequent to 1981. While the 1980 data does reflect a fairly good representation of the relative values of depreciation using the two methods, (see Table 5.3 for Straight Line Method Values) each subsequent year will be biased by the fact that there are no new high discrepancy assets to cancel out the other assets as they progress through their discrepancy cycle. The model could accomodate estimates of future capital expenditures in its present form if the data were developed for the telephone company.

Table 5.3

Comparison of Computer Validation and Actual
Straight Line Depreciation
Expense for 'edmonton telephones'
(1980)

A.	Computer Estimate	24,052,432
B.	(Less Adjustment for 1/2 Year Convention)	1,523,205
C.	Adjusted Estimate	22,529,227
D.	Actual Depreciation*	22,303,284
E.	Difference (C-D)	225,943
F.	Percentage Difference (E/D*100)	1.0 %

* Source: "edmonton telephones'

5.4 RESULTS

The concise representation of the date from the model belies the complexity of the analysis which generated it. To give some indication of rate impacts, the total revenue requirements under each method are presented. As seen in Chapter 4, under a steady state condition, a large part of the discrepancy may actually be caused by the differences in interest expense due to accumulated customer over-payment in earlier years of the Straight Line method. The revenue series therefore should be used only as an indicator of trends in rates within a method, not in relative levels between methods.

During the early part of the life of 'edmonton telephones' (1909 - 1950), the discrepancy in prices between the two methods was quite profound, with the Straight Line Method giving prices up to 2.5 times as high as FASFM (See Figure 5.3).

Besides this generally higher price, the price was also much less stable than FASFM, having several major spikes after large capital expenditures. After this phase of higher than required revenues, the Straight Line Method's capital repayment would have allowed greatly reduced prices in subsequent years, except for the phenomenal rate of growth which kept biasing the prices upwards. Even in this phase, the prices continued to fluctuate. If a regulator were trying to keep prices at a pure cost-recover rate, he would be constantly ordering increases then decreases in prices, even though no fundamental changes in profitability were occuring.

The final phase, subsequent to 1980, shows how the prices would decline using the Straight Line Method if the growth did not continue.

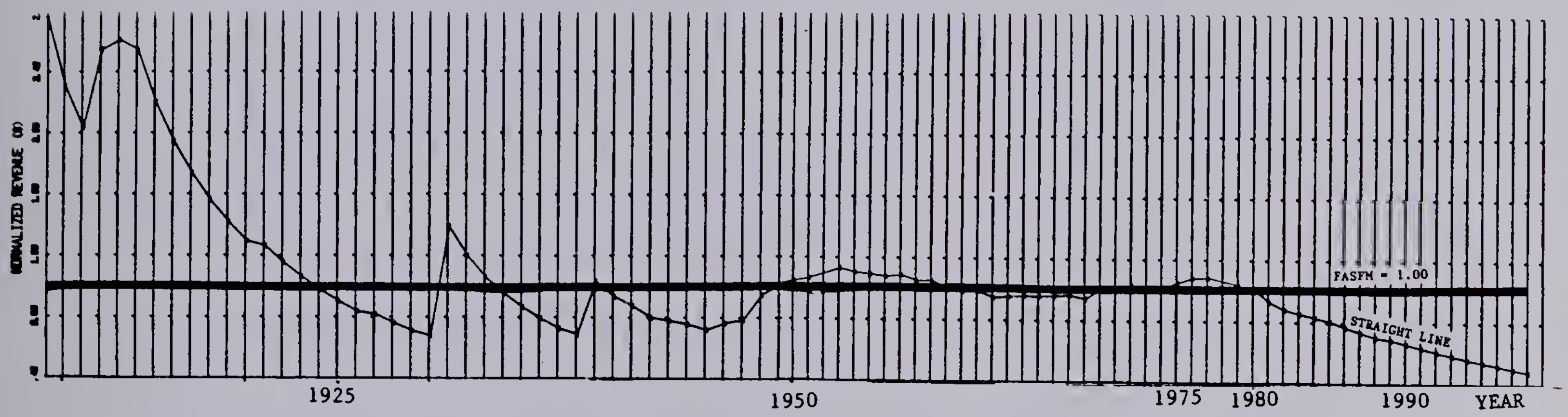


Figure 5.3

Comparative Normalized Revenue
Using FASFM vs Straight Line Depreciation
for 'edmonton telephones' (1909 - 1999)

Similarily, the depreciation expense is also very distorted, in spite of the all the cancelling effects of mixed vintages and fills of the various assets (See Figure 5.4). Unfortunately, the discrepancies in later years are so large that they overshadow discrepancies in the pre-1950 era and are not presented.

The difference in depreciation expense is much more pronounced than the author had expected. For 1980, the FASFM rate is only two-thirds as large as the Straight Line Method using identical asset data for both (See Table 5.4)

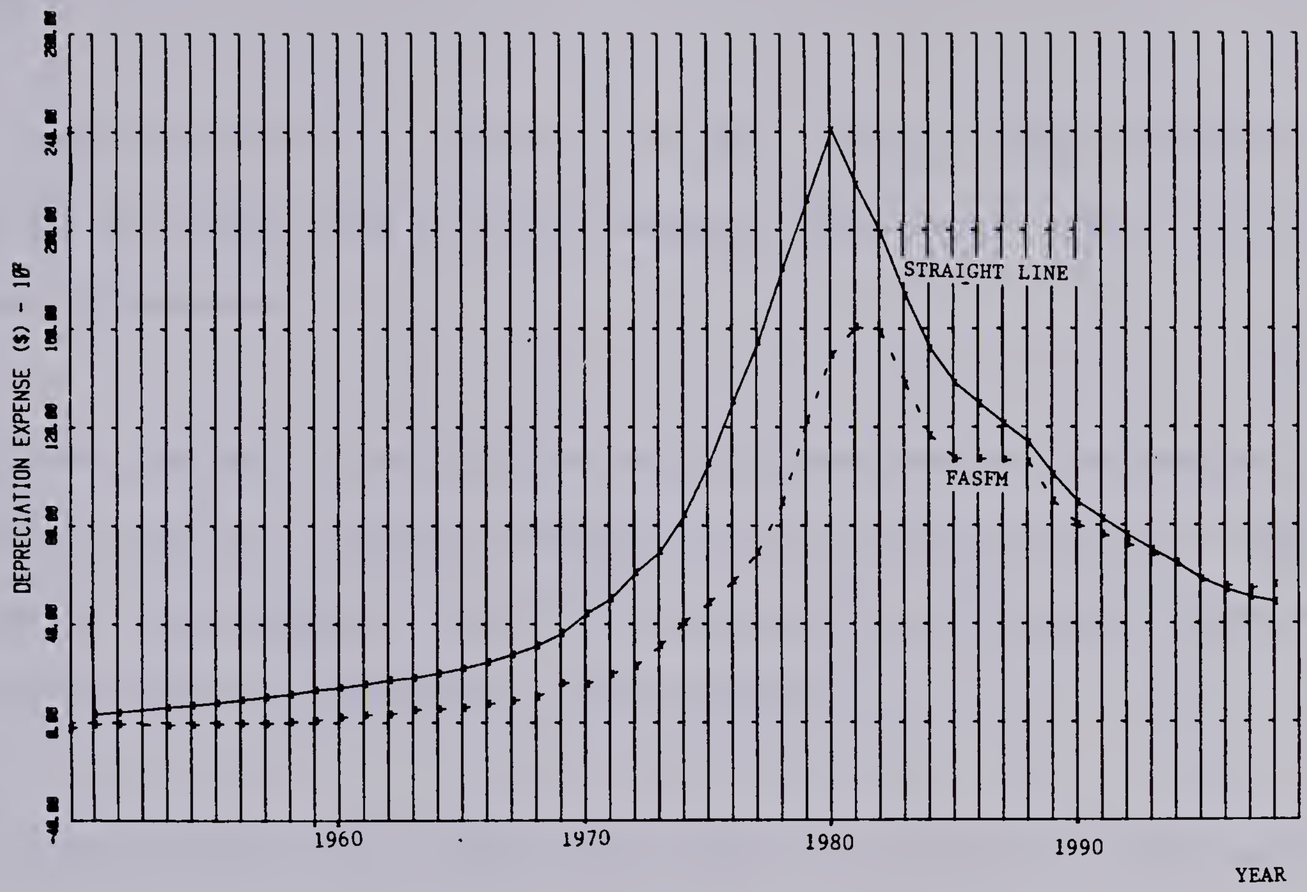


Figure 5.4

Comparison of Depreciation Expenses
Straight Line vs FASFM
'edmonton telephones'
(1950 - 1990)

Table 5.4

Comparative Depreciation for 'edmonton telephones'
Using FASFM vs Straight Line Depreciation (1980)

a.	Straight Line Depreciation	$24,052,432
b.	FASFM Depreciation	$14,915,794
c.	Difference (a-b)	$ 9,136,638
d.	Percentage Difference (c/a x 100)	38.0%

SUMMARY

This chapter tests the calculation of the Straight Line Depreciation Method and the FASFM using identical empirical data from a typical utility 'edmonton telephones'.

It outlines sources of raw data and explains how some of the changes in technology used by a modern telecommunications company affect the choice of depreciation parameters. This is followed by an explanation of how the fill profiles were determined for various assets.

After outlining the various limitations of the study, none of which caused major concerns, the results of the analysis are presented.

The large discrepancy between the two methods shows the reader that further refinements of the Straight Line Depreciation Mehtod would not yield any significant improvement in pricing compared to a more fundamental change to a completely new method such as the FASFM.

1. W. McCandless, R. Meredith, J. Zavitz, "RAPS, The Key to Effective Capital Spending", Telesis, V.7:10, Three, 1980.

CHAPTER SIX

CONCLUSION

6.0 GENERAL

While the previous chapters have adequately shown the mechanisms and magnitude of the discrepancy between the Straight Line Method and FASFM, a pragmatic decision still remains whether or not to employ the more theoretically proper method. The FASFM is not without its shortcomings. These can be categorized into three areas:

1) Cash Flow Effects,
2) Increased Risk, and
3) Transition Problems

6.1 CASH FLOW EFFECTS

Perhaps the single most problematic aspect of FASFM is its dramatic effect on timing of revenues and the resulting impact on financing requirements. In almost all cases, revenue, a cash flow item, is deferred. Although depreciation is also deferred, resulting in no change in net income, it is a non-cash flow item, and therefore offers no relief from the heavy financing burden. While this is less of a constraint for a government organization, many private utility firms would be hard-pressed, even in an essential, monopoly service, to convince investors or bondholders to wait well past the

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

middle of an asset's life before the majority of their investment was recovered.

Of course, this change in cash flow pattern is a relative rather than an absolute measure. Relative to the revenue requirements based on immediately expensing of capital expenditures, the Line Method itself results in prices which require substantial reduction in early period cash flows. Since the previous chapters cast at least some doubt of the absolute properness of the Straight Line Method, perhaps its very use as a benchmark is invalid.

The true measure would be, in fact, whether the money market would tolerate the unorthodox cashflow which FASFM generates. In the absence of any definitive evidence, the concern over cash flow effects becomes more a matter for speculation than argument.

6.2 INCREASED RISK

Although related to the deferred cashflows, this shortcoming looks beyond the practical problems of actually raising capital, to the theoretical aspect of the increased risk of deferring cash flows.

First, the onset of functional obsolescence in some utility hardware is very abrupt, and even in a monopoly situation, could leave a utility holding a much larger part of a plant unrecovered at the time of an unpredicted early retirement than would the conventional Straight Line depreciation method.

Second, and more generally, whenever a receipt of cash is put further into the future, it is exposed for a longer time to the ever-present market vagaries and natural calamities which could preclude its being received. Since FASFM tends to defer receipts, it is more risky. Any inflation aggravates this deferral mechanism further.

There is no denying the increase in risk. In fact, it would be commendable to give the owner of a utility an increased return on investment for exposing himself to this risk.

Suppose that was exactly what the regulator did. In the process of determining this adjustment, he would have to assess the actual risk expected. If the money market felt the adjustment was too small, it would withhold its funds. If the regulator appeared too generous, the market would gladly invest the funds. Over time, regular market arbitrage would finally force this risk adjustment to the perceived "proper" level.

Even with the adjustment applied to FASFM prices, there is enough discrepancy between the two tested methods that the risk adjusted FASFM price for utility service would still be closer to Graham's "ideal price" (which sets the same real price for each unit of a utility service consumed regardless of the year of consumption) than they would with pure Straight Line deprecation.

To some extent, firms producing under perfect competition could be

thought of as adjusting their implicit revenue requirements downward during the formative years when their assets are filling up. Even though their apparent rate of return says they are losing money, and they should theoretically exit from the market, they continue to sell at the market price until their firm matures to a point where market price returns them a profit. One could argue that they have implicitly calculated their depreciation method according to the FASFM process.

6.3 TRANSITIONAL PROBLEMS

Suppose a regulator decided there was some validity to FASFM. His choice of actions could fall anywhere along the following continuum:

1) Retain the status quo.
2) Accept the Straight Line Method but spend considerably less time reviewing the depreciation expense calculations based on the Straight Line Method.
3) With the awareness of the "over charging" in prior years, use the Straight Line Method, but more closely assess the prudency of the rate base and the possibility of lowering prices in the future.
4) Adopt the FASFM.

If the regulator chose to use FASFM, he would be faced with at least two serious transitional problems.

First, unless the utility was absolutely new, it would probably have over-charged in the past. The regulator would have to decide whether a refund was legal or practical. If not, he would have to decide whether the over-charging should be applied against future rates or be given to the utility as a windfall profit.

Secondly, he would have to decide on a method to deal with abrupt changes in estimated asset characteristic, especially service life and survivor curve shapes. The most likely choice would be to deal with the problem in exactly the same manner as commonly practiced using the Straight Line Method, namely to recover all remaining costs over the remaining life. Since the remaining costs would usually be higher using FASFM, the regulator may wish to make some pragmatic modifications to this procedure.

SUMMARY

Even though FASFM results in more reasonable rates than the Straight Line Method, the regulator still has a hard decision to make in deciding to adopt it. The worst shortcoming of the FASFM is its great affect on cash flows. The regulator would have to decide how important a factor this is. He would also have to consider adjusting for the inherent financial risks added by the FASFM. Finally, he would have to resolve serious transitional problems.

Perhaps the best compromise with the least disruption is to continue to use Straight Line Depreciation to calculate revenue

requirements but also to evaluate prices using FASFM and use this information to diagnose the "real" need for a rate increase.

If nothing else, this would tend to smooth out the inherent oscillations of a purely Straight Line approach to the calculation of the depreciation expense.

BIBLIOGRAPHY

Periodicals

Altepeter, H.M. "Plan to Reduce Cost of Outside Plant", Telephony, p. 105-109, January 17, 1977.

Aversch, H., and L.L. Johnson. "Behavior of the Firm Under Regulatory Constraint", American Economic Review, V.52:1053-69, December 1962.

Bailey, E., and R. Coleman. "The Effects of Lagged Regulation in an Aversch - Johnson Model", Bell Journal of Economics and Management Science, Vol. 2, No. 1:278-292, Spring, 1971.

Bennett, J.W. "Accounting for Real Estate Development Operations - Another View", Canadian Charted Accountant, V.100:29, April, 72.

Bullock, C.L. "Accounting Conventions and Economic Reality", Journal of Accounting Research, V.XLIV:22, July, 1974.

Burt, O.R. "A Unified Theory of Depreciation", Journal of Accounting Research, V.10:29, Spring, 1972.

Campbell, W.A. "Fixed Asset Accounting: The Allocation of Costs", Cost and Management, V.50, No.2:51-56, March - April, 1976.

Forsyth, J.D. "Roles of the Equal - Life Group Depreciation Method", Cost and Management, V.46, No.4:33-37, July - August, 1972.

Freidman, A.F. and R.D. White. "A Logical Method of Depreciating Buildings", Appraisal Journal, V.XLII, No.4:549-564, October, 1974.

Gawronski, G.F. "How Equal Life Group Depreciation Can Ease the Telco Financing Burden", Telephony, p. 110, September, 1975.

Horwitz, B. and A. Young. "Extra-Ordinary Gains and Losses and Security Prices", Quarterly Review of Economics and Business, V.14:108, Winter, 1974.

Johnson, O. "Two General Concepts of Depreciation", Journal of Accounting Research, V.6, No.1:36, Spring, 1968.

Keran, M.W. "Inflation, Regulation and Utility Stock Prices", Bell Journal of Economics, pp. 268-280, Spring 1976.

Kimball, B.F. "General Theory of Plant Account Subject to Constant Mortality Law of Retirement", Econometrics, No. 11, Vol. 2:61, 1943.

Maher, R. "Let's Take Some of the Guesswork Out of Depreciation", Telephone Engineer and Management, p. 51, September 15, 1975.

McCandless, W., R. Meredith and J. Zavitz. "RAPS, The Key to Effective Capital Spending", Telesis, V.7:10, Three, 1980.

Reynolds, I. "Selecting the Proper Depreciation Method", The Accounting Review, V.XXXVI, No.2:239-248, April, 1961.

Sosnick, S.H. "Depreciation: The Offsetting Interest Method", The Accounting Review, V.37:65, January, 1962.

Sprague, J.C. "How to Design Telephone Facilities for Life in the Big City - Economically", Telephony, p. 74-80, November 21, 1977.

Sussman, M.R. "Depreciation Revisited", Public Utility Fortnightly, V.85, No.4:31-35, February 26, 1970.

Vatter, W.J. "Accounting For Leases", Journal of Accounting Research, V.4:148, Autumn, 1966.

Books

Accounting Standards Steering Committee. Accounting for Depreciation. London: Institute of Chartered Accountants, 1975, 6 pp.

Accounting Principles Board. Accounting Principles, Original Pronouncements, Volume Two. New York: Commerce Clearing House, 1971, 400 pp.

American Telephone and Telegraph Company. Engineering Economy. 3rd ed. New York: McGraw Hill, 1977, 516 pp.

Baxter, W.T. Depreciation. London: Sweet and Maxwell, 1971, 176 pp.

Bonbright, J.C. Principles of Public Utility Rates. New York: Columbia University Press, 1961, 433 pp.

________. Railroad Capitalization. New York: AMS Press, 1969, 445 pp.

________. Public Utilitities and the National Power Policies. New York: Da Capo Press, 1972, 82 pp.

Bryant, J.M., and R.R. Hermann. Elements of Utility Rate Determination. New York: McGraw - Hill, 1940, 445 pp.

Bussing, I. Public Utility Regulations and the So-Called Sliding Scale. New York: AMS Press, 1968, 174 pp.

Commerce Clearing House. 1965 Depreciation Guide Including New Liberalized Rules. New York: Commerce Clearing House, 1965, 206 pp.

Coughlan, J.D., and W.K. Strand. Depreciation, Accounting, Taxes, and Business Decisions. New York: Ronald Press Company, 1969, 310 pp.

Dirlam, J.B., and A.E. Kahn. Fair Competition - The Law and Economics of Anti-trust Policy. New York: Cornell University Press, 1954, 301pp.

Drebin, A.R., and H. Bierman, Jr. Managerial Accounting: An Introduction. Philadelphia: W.B. Saunders, 1978, 371 pp.

Farris, M.T., and R.J. Sampson. Public Utilities: Regulation, Management, and Ownership. Boston: Houghton Mifflin, 1973, 355 pp.

Fowler, R.F. The Depreciation of Capital Analytically Considered. London: Kraus Reprint, 1980, 143 pp.

Garfield, P.J., and W.J. Lovejoy. Public Utility Economics. New Jersey: Prentice - Hall, 1964, 505 pp.

Goldschmidt, Y. Information for Management Decisions. Ithaca: Colonial Press, 1980, 309 pp.

Gordon M., and G. Shillinglaw. Accounting, A Management Approach. Illinois: Irwin, 1969.

Government of Canada. Financial Statistics on Canadian Telecommunications Common Carriers, 1978. Ottawa: Department of Communications, 1979, 206 pp.

Grant E.L., and P.T. Norton, Jr. Depreciation. New York: Ronald Press, 1965.

Graham, W.J. Public Utility Valuation. Chicago: University of Chicago Press, 1934, 94 pp.

Ijiri, Y. Theory of Accounting Measurement. Carnegie - Mellon: American Accounting Association, 1975, 203 pp.

Iowa State University. Proceedings of the Fifteenth Annual Conference on Public Utility Valuation and Rate Making Process. Ames: Iowa State University, 1976, 199 pp.

Kiezer, N.F. Economics: Analysis and Policy. New York: John Wiley and Sons, 1965.

King, C.W., and G.R. Faust. Telecommunications Cost Inquiry, Supplemental Report of the Consultants - Depreciation. Canadian Transport Commission, 1976, 125 pp.

Klass, M.W., and W.G. Sheppard. Regulation and Entry. Michigan: MSU Public Utility Papers, 1976.

Lamden, C.W., D.L. Gerboth and T.W. McRae. Accounting for Depreciable Assets. New York: American Institute of Certified Public Accountants, 1975, 181 pp.

Lancaster, K. Introduction to Microeconomics. Chicago: Randy McNally, 1974, 357 pp.

Malchman, L. H., and A. Slavin. Foundations of Accounting for Managerial Control. Philadelphia: Chilton, 1959.

Meij, J.L. Depreciation and Replacement Policy. Amsterdam: North - Holland, 1961, 236 pp.

Musgrave, R.A. The Theory of Public Finance, a Study in Public Economy. New York: McGraw - Hill, 1959, 621 pp.

________, and A.T. Peacock. Classics in the Theory of Public Finance. Toronto: MacMillan, 1967, 243 pp.

________, and P.B. Musgrave. Public Finance in Theory and Practice. New York: McGraw - Hill, 1980, 819 pp.

National Association of Manufacturers of the United States. Depreciation Policy and the Reserve Ratio Test. New York: National Association of Manufacturers, 93 pp.

Parker, J.R. Accountancy, A Source Book of Readings. Toronto: Pitman, 1971, 515 pp.

Samuelson, P.A. Economics, 10th ed. New York: McGraw - Hill, 1973.

Smith, G.R. Engineering Economy. Ames: Iowa State University Press, 1979, 579 pp.

Spurr. H.C. Guiding Principles of Public Service Regulation, Rochester: Public Utility Reports, Inc., 1924, 752 pp.

Statutes of Alberta. The Public Utilities Board Act.

Stelzer, I.M. Pricing in Regulated Industries; A Not-So-Marginal Problem. ed. J.E. Haring. Los Angeles: Economics Research Centre, 1968, 207 pp.

Tax Foundation. Depreciation Allowances: Federal Tax Policy and Some Economic Aspects. New York: Tax Foundation, Inc., 1970, 64 pp.

Terbough, G. Realistic Depreciation Policy. Chicago: R.R. Donnelly and Sons, 192 pp.

Ture, N.B. Accelerated Depreciation in the United States. New York: Columbia University Press, 1967, 235 pp.

Welsch, G.A., C.T. Zlatkovich, D.A. Wilson and M. Zin. Intermediate Accounting. Georgetown: Irwin-Dorsey, 1976, 1068 pp.

Winfrey, R. "Condition - Percent Tables for Depreciation of Unit and Group Properties", Iowa State College, Engineering Experiment Station, Bulletin 156, 1942.

APPENDIX A

COMPUTER PROGRAM LOGIC AND DATA

A.0 GENERAL

While none of the calculations involved in calculating either straight line or FASFM depreciation are too complex to be done by hand, the volume of data gathered and manipulated is unworkably large to handle manually.

First, the telephone company has over sixty account codes to differentiate the many varied types of assets (See Enclosure A.1). For each of these, there are several vintages, some as far back as 1909. For every vintage, there may be as many as 125 equal life groups, (See Figure 1). Each one of these equal life groups can have a different fill pattern.

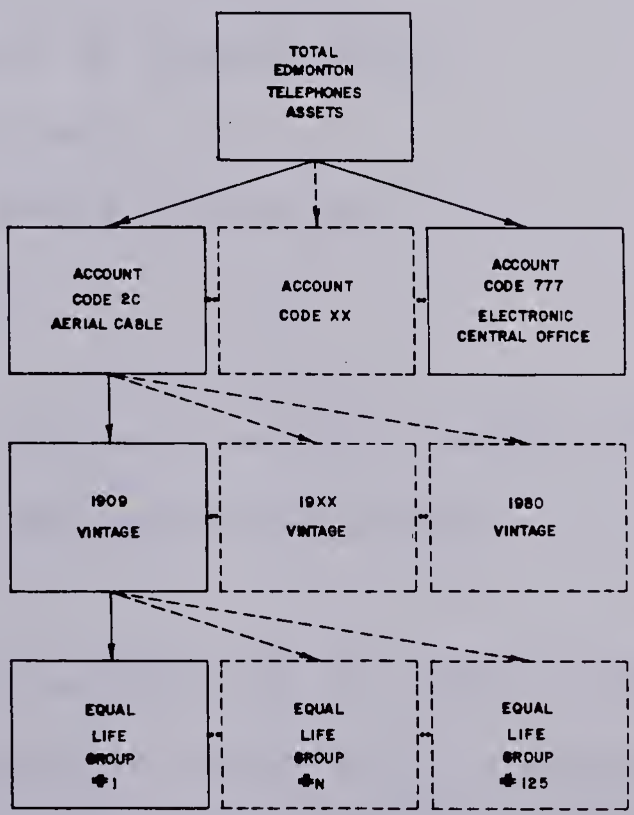


Figure A.1

Heirarchy of Asset Groups

This appendix shows how the computer programs, all run on the *FORTH compiler, manipulate the raw physical utility data into a concise output. Analysis proceeds in four steps:

1) Core logic,
2) Expanded logic,
3) File Structure, and
4) Default Data.

A.1 CORE LOGIC

Although the program has several added feature to assist input and output, the essential core of the program is a small routine which takes five parameters of a single asset, namely:

1) Original value of the asset ($),
2) Salvage value (% of original value),
3) Service life (years),
4) Fill Profile (units by year), and
5) Interest rate,

and calculates, by year, both the Straight Line Depreciation Expense and the FASFM Depreciation Expense.

The method used to calculate the two expense streams is laid out in Chapter 2 (sections 2.3.1 and 2.3.2 (2), respectively). While the computer takes some computational short-cuts, they are mathematically equivalent to the manual methods shown in Chapter 2.

Using these calculations, selected balance sheet and income statement items are also calculated and presented. This simplified process is done by the less sophisticated program, "COMPARE .0".

A.2 EXPANDED LOGIC

Utilities are not usually made up to single assets, and therefore, certain enhancement to the core process have been added and make up the more comprehensive program, "GLOBE.0" (See Enclosure A.2).

A.2.1 Fill Profile Calculation

Although it is possible to input a discrete fill profile for every single asset, it would be practically impossible to do so for such a large number of assets. Therefore, the program has a facility to calculate a fill profile from a small set of parameters.

A.2.2 Equal Life Group Splits

For mass assets, accounts which include very large numbers of homogeneous assets which retire according to some actuarial survivor curve, it is easier to have the computer determine which assets will last how long, rather than inputting the original value of each Equal Life Group discretely.

The program accomplishes this by reading in 31 different survivor curve shapes (See Appendix B), each expressing the percentage of

survivors left after each percentage of average service life (from 0 to 450 percent, in one percent increments). These curves exist in a 'edmonton telephones' computer file and were transmitted to the University of Alberta computer via a Lanpar WS/78 Word Processor.

As each vintage of account is read in, the computer splits it up into a series of Equal Life Groups and passes each one in turn to the core logic for individual processing.

A.2.3 Global Summarizing

Although each Equal Life Group is individually analyzed by the computer, the results of each of the several parameters must be summed together across all the single assets to arrive at the composite effect for the entire company. When this is done, some of the statistics presented in "COMPARE.O" (see Enclosure A.3) are meaningless and are not presented. Other statistics are substituted (see Enclosure A.4). Some statistics are summed as the program progresses through the assets while other, such as composite rate of return) can only be calculated after the total asset complement has been processed (see Enclosure A.5).

A.3 File Structure

Because of the large quantitiy of data used in the process, rather than storing the data internally in the program, much of the data is read in from data files when the program is run.

For analyzing the effects of different rates of growth, a small program, GROWTH.0, actually calculates the required pattern of asset additions and places this data in an output file which was used as input (asset data) file for the main program (see Figure A.2).

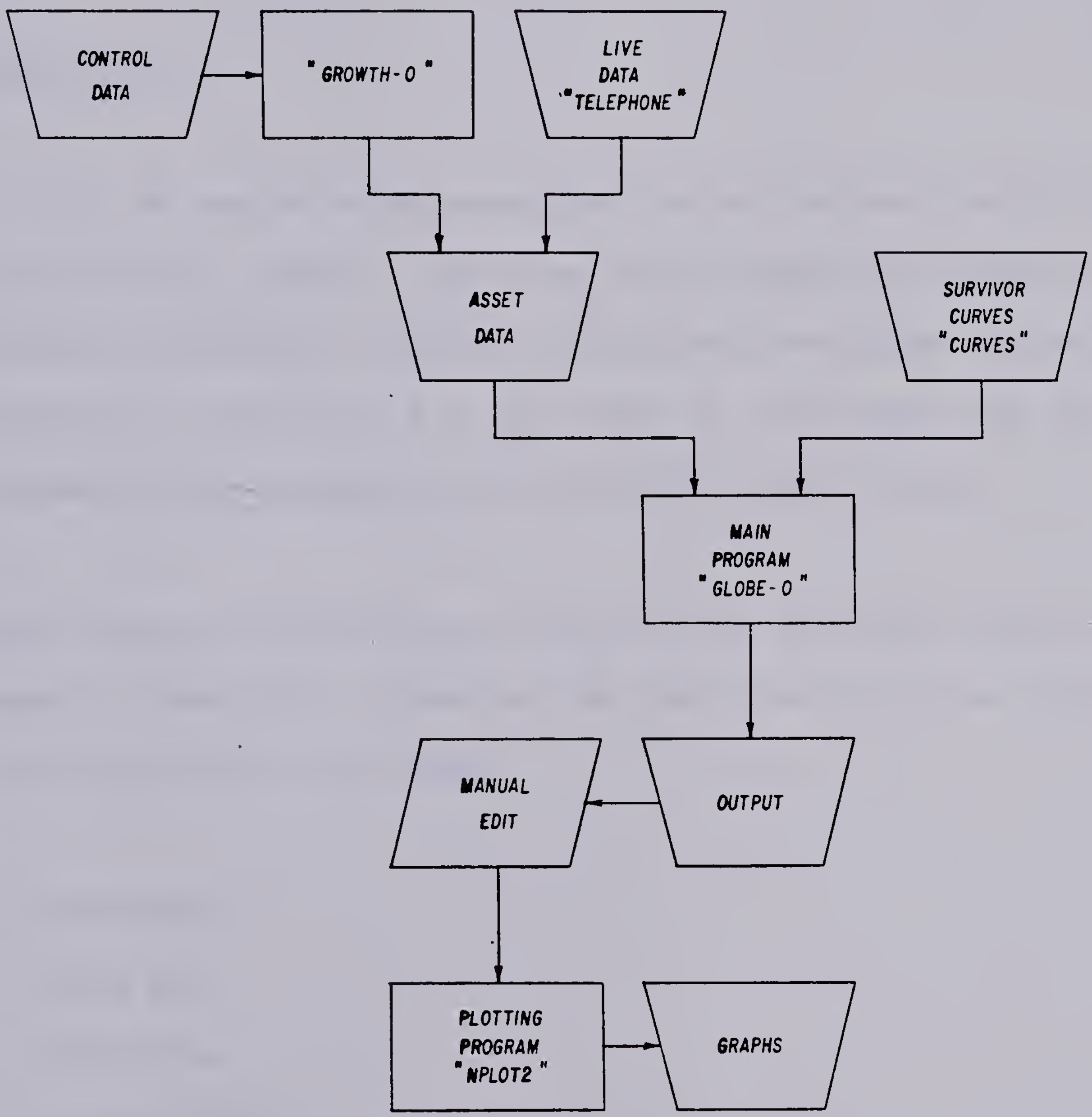


Figure A.2

Schematic File Structure

Almost all the graphs were produced using a custom graphing package running on an 'edmonton telephones' DEC 11/70 computer. This

graphing package automatically chooses a "nice" scale for the given range of data. By reducing turnaround time, the routine proved invaluable in choosing the most illustrative parameters for conveying the complex effects of different combinations of assumptions.

A.6 Default Data

For each of the six major parameters tested (interest rate, fill, service life, growth, survivor curve shape and inflation), different assumptions were made for the basic variables. These are presented in Enclosure A.6 and serve to demonstrate the actual complexity of the analysis which the brief output belies.

Sample pages of the empirical data are also presented, showing the compact format for collecting the asset data at the account code/vintage level, including:

1) Description
2) Asset Type
3) Curve Shape
4) Original Value
5) Salvage Value
6) Service Life
7) Fill Type
8) Fill Profile Intercept
9) Fill Profile Slope

2C-AERIAL-CABLE-----	2	12	45	27280.	-2.	17	2	0.20000	0.20000
--------------------	2	12	46	15482.	-2.	17	2	0.20000	0.20000
--------------------	2	12	47	76306.	-2.	17	2	0.20000	0.20000
--------------------	2	12	48	68486.	-2.	17	2	0.20000	0.20000
--------------------	2	12	49	133693.	-2.	17	2	0.20000	0.20000
--------------------	2	12	50	139166.	-2.	17	2	0.20000	0.20000
--------------------	2	12	51	127940.	-2.	17	2	0.20000	0.20000
--------------------	2	12	52	144249.	-2.	17	2	0.20000	0.20000
--------------------	2	12	53	225719.	-2.	17	2	0.20000	0.20000
--------------------	2	12	54	118104.	-2.	17	2	0.20000	0.20000
--------------------	2	12	55	172927.	-2.	17	2	0.20000	0.20000
--------------------	2	12	56	330108.	-2.	17	2	0.20000	0.20000
--------------------	2	12	57	373969.	-2.	17	2	0.20000	0.20000
--------------------	2	12	58	315342.	-2.	17	2	0.20000	0.20000

Figure A.3

Sample of Empirical Data Input File - "TELEPHONE"

SUMMARY

The program, although relatively short and of medium complexity, does a great deal of work. From a large, yet economical amount of data, it can very acurately determine the relative statistical characteristics of the two depreciation methods and distill this data into a workable amount of output. This method could be quite easily adopted to any utility with good asset data and would be useful for both owners and regulators of utilities.

EDMONTON TELEPHONES ASSET DESCRIPTION/ACCOUNT CODE SUMMARY

DESCRIPTION	ACCOUNT CODE
Poles	1C
Aerial Cable	2C
Vaults and Ducts	4C
Underground Cable	5C
Central Office Buildings	10C
Other Buildings	11C
Central Office Equipment - Step-by-Step	17C
Teletype Connections	18C
Land	21C
Calrs Equipment	26C
Central Office Equipment - Tools	27C
Station Connections	28C
Building Cable	32C
Central Office Equipment - Circuit	37C
Station Connection - Phone Center Jacking	38C
Central Office Equipment - Crossbar	47C
Coaxial Cable - Service Entrance	48C
Large PABX's	58C
Buried Cable	65C
Fire Alarms	68C
Sound Systems	108C
Teletype	118C
Station Apparatus	128C
Radio Telephones	138C
Radio Pagers	139C
Apartment Enterphone	140C
Coin Telephones	148C
Data Sets	168C
AMR - Field Costs	178C
Telephone Answering Equipment	198C
Fibre Optics	235C
Central Office - Circuit	257C
Subscriber Circuit Terminating Equipment	158C
Buried Coaxial Cable	265C
AMR - Central Office Equipment	277C
Fibre Optics - Outside Plant	305C
Large Electronic PABX	358C
Fibre Optics - Buried	365C
Electronic Subscriber Equipment	428C
Closed Circuit Television	458C

ANI - Crossbar	547C
Prepackaged PABX	558C
COE - Radio Telephone	567C
COE - Radio Paging Equipment	568C
COE - Digital	577C
Prepackaged Electronic PABX	658C
COE Electronic	777C
Furniture	26100
Vehicles	26401
Tools	26405
Test Equipment	26406
Computers - DEC 11/70	8105658
Computers - Directory Assistance	8105658
Excess of Costs - Jasper Place Acquisition	n/a

```
      DIMENSION FILL(125),PWCUYR(125),OUTBAL(126),TOSLEX(125)
      DIMENSION QINSEX(125),QINFEX(125),CUSDEP(125)
      REAL*8 PERASL
      DIMENSION  SUR(450,31),TSUR(10)
      DIMENSION SLRATE(125),REVSL(125),NETSIC(125),ARR(125),REPAYS(125)
      DIMENSION GL(20,205),GNOREV(205),GSARR(205),GFARR(205),GHARR(205)
      DIMENSION CASH(125),FSFDEP(125),DBALFS(126),REPYFS(125)
      DIMENSION NETFIC(125),TDFSEX(125),NTHYIC(125),TDHYEX(125)
      DIMENSION ARRFSF(125),IYEARS(10),ARRHYB(125),CUFDEP(125)
      LOGICAL EQUC
      LOGICAL*1 DESCRP(20),AT
      REAL NETFIC,NTHYIC,INTRST,NETSIC
      INTEGER FILL,CUCUYR,FILTYP,ASSTYP,CURSHP,BASEYR
      DATA AT/'@'/
      CALL FREAD(5,'I:',ASSTYP)
      IF(ASSTYP.EQ.1) GO TO 51
      DO 50 L=1,31
      DO 50 K=1,45
      CALL FREAD(4,'R V:',TSUR(1),10)
      DO 50 J=1,10
      SUR((K-1)*10+J,L)=TSUR(J)
   50 CONTINUE
   51 CALL FREAD(5,'R:',INTRST)
      PLNT=1.+INTRST
      DO 53 J=1,205
      DO 53 K=1,20
      GL(K,J)=0.
   53 CONTINUE
      MINBAS=150
  231 CALL FREAD(5,'STRING:',DESCRP(1),20,'3I:',ASSTYP,CURSHP,BASEYR,'2R
     *:',VALUE,SAL,'2I:',LIFE,FILTYP,'2R:',FILPR1,FILPR2)
      IF(EQUC(DESCRP(1),AT)) GO TO 665
      WRITE(6,2005)(DESCRP(J),J=1,20),ASSTYP,CURSHP,BASEYR,VALUE,SAL,LIF
     *E,FILTYP,FILPR1,FILPR2
 2005 FORMAT(' ',20A1,3(2X,I3),2X,F11.2,2X,F3.0,2(2X,I3),2(3X,F7.5))
      MINBAS=MINO(BASEYR,MINBAS)
      IF (ASSTYP.EQ.1) GO TO 95
  562 IELG=0
      IF(CURSHP.GT.39) CURSHP=CURSHP-2
      IF(CURSHP.GT.19) CURSHP=CURSHP-2
      CURSHP=CURSHP-9
      ITLIFE=LIFE
      TVALUE=VALUE
      PSTSUR=1.
  560 IELG=IELG+1
      IF ((ITLIFE*1.).EQ.0) WRITE (6,2004) ITLIFE
 2004 FORMAT(' ITLIFE.EQ.',I4)
      PERASL=(IELG*1.)/(ITLIFE*1.)*100.
      IPCASL=PERASL
      IF(IPCASL.LT.1) WRITE(6,2011) IPCASL
 2011 FORMAT(' IPCASL.EQ.0',I4)
      IF(IPCASL.GT.448) WRITE(6,2012) IPCASL
 2012 FORMAT(' IPCASL.EQ.448',I4)
      SURVIV=SUR(IPCASL,CURSHP)-(SUR(IPCASL,CURSHP)-SUR(IPCASL+1,CURSHP)
     *)*(PERASL-IPCASL)
      VALUE=TVALUE*(PSTSUR-SURVIV)
      IF (VALUE.GT..01) GO TO 561
      IF(SUR(IPCASL,CURSHP).NE.0.) GO TO 560
  561 PSTSUR=SURVIV
      LIFE=IELG
   95 IF (FILTYP-2) 100,102,103
  100 DO 101 J=1,LIFE
      FILL(J)=1
  101 CONTINUE
      GO TO 104
  102 DO 106 J=1,LIFE
      IF((FILPR2*LIFE).EQ.0.) WRITE(6,2006) FILPR2
 2006 FORMAT(' FILPR2.EQ.',F9.2)
      FILSPO=(1-FILPR1)/(FILPR2*LIFE)
      FILL(J)=MINO(INT(100*(FILPR1+FILSPO*(J-1))),100)
      IF(FILL(J).EQ.0) WRITE(6,2010) FILL(J),J
 2010 FORMAT(' FILL.EQ.0 LINE 51.4',2I5)
  106 CONTINUE
      GOTO 104
  103 IF(ASSTYP.EQ.2) GO TO 100
      CALL FREAD(5,'I V:',FILL(1),LIFE)
  104 AMTVAL=VALUE-SAL/100.*VALUE/(PLNT)**LIFE
      CUCUYR=0
      CPWCYR=0.
      DO 55 J=1,LIFE
      FSFDEP(J)=0.
   55 CONTINUE
   70 DO 105 J=1,LIFE
      PWCUYR(J)=FILL(J)/(PLNT)**J
      CPWCYR=CPWCYR+PWCUYR(J)
      CUCUYR=CUCUYR+FILL(J)
  105 CONTINUE
      IF(CPWCYR.EQ.0) WRITE(6,2007) CPWCYR
 2007 FORMAT(' CPWCYR.EQ.',F9.2)
      IF(LIFE.EQ.0) WRITE(6,2008) LIFE
 2008 FORMAT(' LIFE.EQ.0',I4)
      RATFSF=AMTVAL/CPWCYR
  110 DO 130 J=1,LIFE
      CASH(J)=FILL(J)*RATFSF
  130 CONTINUE
      IF(LIFE.EQ.1) GO TO 411
      LFMIN1=LIFE-1
      DO 410 J=1,LFMIN1
      FSFDEP(J)=0.
      JPLUS=J+1
      DO 390 I=JPLUS,LIFE
      FSFDEP(J)=FSFDEP(J)+CASH(I)/(PLNT)**(I+1-J)-CASH(I)/(PLNT)**(I-J)
  390 CONTINUE
      FSFDEP(J)=CASH(J)/(PLNT)+FSFDEP(J)
  410 CONTINUE
  411 FSFDEP(LIFE)=CASH(LIFE)/(PLNT)
      SLDEP= (VALUE-SAL/100.*VALUE)/LIFE
      OUTBAL(1)=VALUE
      DBALFS(1)=VALUE
      DO 650 K=1 ,LIFE
      KB=K+BASEYR
      CUSDEP(K)=SLDEP*K
      QINSEX(K)=OUTBAL(K)*INTRST
      TOSLEX(K)=SLDEP+QINSEX(K)
      IF(FILL(K).EQ.0) WRITE(6,2009) FILL(K),K
 2009 FORMAT(' FILL LINE 94 .EQ.0',I4,I4)
      SLRATE(K)=TOSLEX(K)/FILL(K)
      REVSL(K)=TOSLEX(K)
      NETSIC(K)=REVSL(K)-TOSLEX(K)
      IF(OUTBAL(K).EQ.0) GO TO 744
```

```
      ARR(K)=(NETSIC(K)+QINSEX(K))/OUTBAL(K)
      GO TO 745
  744 ARR(K)=0.
  745 REPAYS(K)=SLDEP+NETSIC(K)
      OUTBAL(K+1)=OUTBAL(K)-REPAYS(K)
      QINFEX(K)=DBALFS(K)*INTRST
      TOFSEX(K)=QINFEX(K)+FSFDEP(K)
      IF (K.EQ.1) GO TO 748
      CUFDEP(K)=CUFDEP(K-1)+FSFDEP(K)
      GO TO 749
  748 CUFDEP(K)=FSFDEP(K)
  749 NETFIC(K)=CASH(K)-TDFSEX(K)
      REPYFS(K)=NETFIC(K)+FSFDEP(K)
      DBALFS(K+1)=DBALFS(K)-REPYFS(K)
      TDHYEX(K)=QINFEX(K)+SLDEP
      NTHYIC(K)=CASH(K)-TOHYEX(K)
      IF(DBALFS(K).EQ.0.) GO TO 747
      ARRFSF(K)=(NETFIC(K)+QINFEX(K))/DBALFS(K)
      ARRHYB(K)=(NTHYIC(K)+QINFEX(K))/DBALFS(K)
      GO TO 746
  747 ARRFSF(K)=0.
      ARRHYB(K)=0.
  746 GL(1,KB)=GL(1,KB)+CUSDEP(K)
      GL(2,KB)=GL(2,KB)+SLDEP
      GL(3,KB)=GL(3,KB)+QINSEX(K)
      GL(4,KB)=GL(4,KB)+TDSLEX(K)
      GL(5,KB)=GL(5,KB)+REVSL(K)
      GL(6,KB)=GL(6,KB)+NETSIC(K)
      GL(7,KB)=GL(7,KB)+OUTBAL(K)
      GL(8,KB)=GL(8,KB)+REPAYS(K)
      GL(9,KB)=GL(9,KB)+OUTBAL(K+1)
      GL(10,KB)=GL(10,KB)+CUFDEP(K)
      GL(11,KB)=GL(11,KB)+FSFDEP(K)
      GL(12,KB)=GL(12,KB)+QINFEX(K)
      GL(13,KB)=GL(13,KB)+TOFSEX(K)
      GL(14,KB)=GL(14,KB)+CASH(K)
      GL(15,KB)=GL(15,KB)+NETFIC(K)
      GL(16,KB)=GL(16,KB)+DBALFS(K)
      GL(17,KB)=GL(17,KB)+REPYFS(K)
      GL(18,KB)=GL(18,KB)+DBALFS(K+1)
      GL(19,KB)=GL(19,KB)+NTHYIC(K)
      GL(20,KB)=GL(20,KB)+TOHYEX(K)
  650 CONTINUE
      IF(ASSTYP.EQ.1) GO TO231
      IF(SUR(IPCASL,CURSHP).EQ.0.) ASSTYP=1
      IF (ASSTYP.EQ.2) GO TO 560
      GO TO 231
  665 DO 666  J=1,150
      IF (GL(14,J).EQ.0.) GO TO 500
      GNDREV(J)=GL(5,J)/GL(14,J)
      GO TO 510
  500 GNDREV(J)=0.
  510 IF(GL(7,J).EQ.0.) GO TO 520
      GSARR(J)=(GL(6,J)+GL(3,J))/GL(7,J)
      GO TO 530
  520 GSARR(J)=0.
  530 IF(GL(16,J).EQ.0.) GO TO 540
      GHARR(J)=(GL(20,J)+GL(12,J))/GL(16,J)
      GFARR(J)=(GL(15,J)+GL(12,J))/GL(16,J)
      GO TO 666
  540 GHARR(J)=0.
      GFARR(J)=0.
  666 CONTINUE
      IPAGES= 150/10
      DO 652 J=1,IPAGES
      IF (J*10.LT.MINBAS) GO TO 652
      IF ((J+1)*10.LT.MINBAS) GO TO 652
   68 JXTEN=(J-1)*10
      WRITE (6,1006)
      WRITE (6,1006)
      WRITE(6,1110)
      DO 200 N=1,10
      IYEARS(N)=(J-1)*10+N
  200 CONTINUE
      WRITE (6,1120) (IYEARS(N),N=1,10)
      WRITE (6,1006)
      WRITE(6,1130)
      JXTEN=JXTEN+1
      K=9+JXTEN
      WRITE(6,1140)
      WRITE (6,1150)
      WRITE (6,1006)
      WRITE (6,1540) (GL(1,L),L=JXTEN,K)
      WRITE (6,1006)
      WRITE (6,1160) (GL(2,L),L=JXTEN,K)
      WRITE (6,1170) (GL(3,L),L=JXTEN,K)
      WRITE (6,1180) (GL(4,L),L=JXTEN,K)
      WRITE (6,1006)
      WRITE (6,1510) (GNDREV(L),L=JXTEN,K)
      WRITE (6,1200) (GL(5,L),L=JXTEN,K)
      WRITE (6,1210) (GL(6,L),L=JXTEN,K)
      WRITE (6,1220)(GSARR(L),L=JXTEN,K)
      WRITE (6,1006)
      WRITE (6,1530) (GL(7,L),L=JXTEN,K)
      WRITE (6,1230) (GL(8,L),L=JXTEN,K)
      WRITE (6,1240) (GL(9,L),L=JXTEN,K)
      WRITE  (6,1006)
      WRITE (6,1250)
      WRITE (6,1260)
      WRITE (6,1006)
      WRITE (6,1540) (GL(10,L),L=JXTEN,K)
      WRITE (6,1006)
      WRITE (6,1270) (GL(11,L),L=JXTEN,K)
      WRITE (6,1280 ) INTRST, (GL(12,L),L=JXTEN,K)
      WRITE (6,1290) (GL(13,L),L=JXTEN,K)
      WRITE (6,1006)
      WRITE (6,1310) (GL(14,L),L=JXTEN,K)
      WRITE(6,1320) (GL(15,L),L=JXTEN,K)
      WRITE(6,1330)(GFARR(L),L=JXTEN,K)
      WRITE (6,1006)
      WRITE (6,1530) (GL(16,L),L=JXTEN,K)
      WRITE (6,1340) (GL(17,L),L=JXTEN,K)
      WRITE (6,1350) (GL(18,L),L=JXTEN,K)
      WRITE (6,1006)
      WRITE (6,1360)
      WRITE (6,1370)
      WRITE (6,1400) (GL(20,L),L=JXTEN,K)
      WRITE (6,1006)
      WRITE (6,1410) (GL(19,L),L=JXTEN,K)
      WRITE (6,1420) (GHARR(L),L=JXTEN,K)
```

```
      WRITE (6,1130)
  652 CONTINUE
 1006 FORMAT(' ')
 1104 FORMAT('1',T44,'SUMMARY OF SELECTEO INCOME STATEMENT')
 1105 FORMAT(' ',T50,'ANO BALANCE SHEET ITEMS')
 1106 FORMAT(' ',T47,'USING STRAIGHT LINE ANO FASFM')
 1107 FORMAT(' ',T50,'OEPRECIATION TECHNIQUES')
 1108 FORMAT(' ',T44,34(1H-))
 1110 FORMAT(' ',T30,10(6X,'YEAR'))
 1120 FORMAT(' ',T37,10(I3,7X))
 1130 FORMAT(' ',T30,10(6X,'----'))
 1140 FORMAT(' STRAIGHT LINE-TEST YEAR RATES')
 1150 FORMAT(' ',29('='))
 1160 FORMAT( ' OEPRECIATION EXPENSE',T30,10F10.0)
 1170 FORMAT(' INTEREST EXPENSE ',T30,10F10.0)
 1180 FORMAT(' TOTAL EXPENSE',T30,10F10.0)
 1200 FORMAT(' REVENUES',T30,10F10.0)
 1210 FORMAT(' NET INCOME',T34,10F10.4)
 1220 FORMAT(' ACCOUNTING RATE OF RETURN',T34,10F10.4)
 1230 FORMAT(' REPAYMENT',T30,10F10.0)
 1240 FORMAT(' NEW OUTSTANDING OEBT',T30,10F10.0)
 1250 FORMAT(' FASFM-CONSTANT RATES')
 1260 FORMAT(' ====================')
 1270 FORMAT(' OEPRECIATION EXPENSE',T30,10F10.0)
 1280 FORMAT(' INTEREST EXPENSE @',F4.2,')',T30,10F10.0)
 1290 FORMAT(' TOTAL EXPENSE',T30,10F10.0)
 1310 FORMAT(' REVENUE',T30,10F10.0)
 1320 FORMAT(' NET INCOME',T34,10F10.4)
 1330 FORMAT(' ACCOUNTING RATE OF RETURN',T34,10F10.4)
 1340 FORMAT(' REPAYMENT',T30,10F10.0)
 1350 FORMAT(' NEW OUTSTANOING OEBT',T30,10F10.0)
 1360 FORMAT(' STRAIGHT LINE - CONSTANT RATE')
 1370 FORMAT(' ==============================')
 1380 FORMAT(' OEPRECIATION EXPENSE',T30,10F10.0)
 1390 FORMAT(' INTEREST EXPENSE @',F4.2,')',T30,10F10.0)
 1400 FORMAT(' TOTAL EXPENSE',T30,10F10.0)
 2002 FORMAT(' ',130A1)
 1410 FORMAT(' NET INCOME',T30,10F10.0)
 1420 FORMAT(' ACCOUNTING RATE OF RETURN',T34,10F10.4)
 1510 FORMAT(' NORMALIZED REVENUE',T34,10F10.4)
 1530 FORMAT(' OLO OUTSTANOING OEBT',T30,10F10.0)
 2003 FORMAT(' ',F7.5)
 1540 FORMAT(' CUMULATIVE DEPRECIATION',T30,10F10.0)
      STOP
      ENO
```

VARIABLES LIST

Description	Straight-Line	FASFM	Hybrid	General	Type
Interest Rate				INTRST	R(1) (E)
Interest + 1.				PLNT	R(1)
Fill type				FILTYP	I(1) (E)
Fill (by year)				FILL	I(125) (E)
Fill Intercept				FILPR1	R(1)
Fill Slope				FILPR2	R(1)
Units/year fill				FILSPD	R(1)
PW Customer Years		PWCUYR			R(125)
Cumulative Customers	CUCUYR	CPWCYR			R(1)
Historical value				VALUE	R(1)
Temporary value				TVALUE	R(1)
Salvage %				SAL	R(1)
Amortizable Value		AMTUAL			R(1)
Value of ELG(i)				SURVIV	R(1)
Previous Survivors				PSTSUR	R(1)
Life passed to core				LIFE	I(1)
Average Service Life				ITLIFE	I(1)
Life of this ELG				IELG	I(1)
% of Average Service Life				PERASL	R*8(1)
Integer % ASL				IPCASL	I(1)
Vintage				BASEYR	I(1) (E)
Least vintage				MINBAS	I(1)
Life minus one year				LFMIN1	I(1)
Integrated(1) or Mass(2)				ASSTYP	I(1) (E)
Curve shape				CURSHP	I(1) (E)
Survivors that % ASL				SUR	R(450,31)
Temporary Storage - survivor %				TSUR	R(10)
Depreciation Expense	SLDEP(2)	FSFDEP(11)			R(125)
Cumulative Depreciation	CUSDEP(1)	CUFDEP(10)			R(125)
Interest Expense	QINSEX(3)	QINFEX(12)			R(125)
Total Expense	TOSLEX(4)	TOFSEX(13)	TOHYEX(20)		R(125)
Rate	SLRATE	RATFSF			R(1) R(125)
Revenue	REVSL(5)	CASH(14)			R(125)
Normalized Revenue	GNOREV				R(125)
Net Income	NETSIC(6)	NETFIC(15)	NTHYIC(19)		R(125) (E)
Repayment of Debt	REPAYS(8)	REPYFS(17)			R(125)
Outstanding Capital	OUTBAL(7,9)	OBALFS(16,18)			R(126)
Accounting Rate of Return	ARR	ARRFSF	ARRHYB		R(125)
Global ARR	GSARR	GFARR	GHARR		R(125)
Description				DESCRP	A(6)
'blanks'				BLANK	A(6)
'@'				AT	A1
Page counter-output				1PAGE	I(1)
Year - output				1 YEARS	I(1)
Page times ten				JXTEN	I(1)
Miscellaneous loop variables				N,L,I,K,KB J, JPLUS	I(1) I(1)

LEGEND

Numbers in Brackets Indicate Index in Global Matrix

R = Real
I = Integer (size)
E = Explicit

ENCLOSURE A.3

COMPARATIVE SAMPLE OUTPUT

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
	----	----	----	----	----	----	----	----	----	----
PERCENT OF LIFE	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00
UNITS OF SERVICE(TOTAL=1000)	100	100	100	100	100	100	100	100	100	100
PW OF UNITS (CPW= 614.5)	90.61	82.64	75.13	68.30	62.09	56.45	51.32	46.65	42.41	38.55
STRAIGHT LINE-TEST YEAR RATES										
CUMULATIVE DEPRECIATION	1000.00	2000.00	3000.00	4000.00	5000.00	6000.00	7000.00	8000.00	9000.00	10000.00
DEPRECIATION EXPENSE	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00
INTEREST EXPENSE (@0.10)	1000.00	900.00	800.00	700.00	600.00	500.00	400.00	300.00	200.00	100.00
TOTAL EXPENSE	2000.00	1900.00	1800.00	1700.00	1600.00	1500.00	1400.00	1300.00	1200.00	1100.00
RATE	20.00	18.00	16.00	17.00	16.00	15.00	14.00	12.00	12.00	11.00
NORMALIZED RATE	1.23	1.17	1.11	1.04	0.98	0.92	0.86	0.80	0.74	0.68
REVENUES	2000.00	1900.00	1800.00	1700.00	1600.00	1500.00	1400.00	1300.00	1200.00	1100.00
NET INCOME	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ACCOUNTING RATE OF RETURN	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
OLD OUTSTANDING DEBT	10000.00	9000.00	8000.00	7000.00	6000.00	5000.00	4000.00	3000.00	2000.00	1000.00
REPAYMENT	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00
NEW OUTSTANDING DEBT	9000.00	8000.00	7000.00	6000.00	5000.00	4000.00	3000.00	2000.00	1000.00	0.0
FASFM-CONSTANT RATES										
CUMULATIVE DEPRECIATION	627.46	1317.66	2076.68	2912.02	3830.66	4841.20	5952.77	7175.50	8520.50	10000.00
DEPRECIATION EXPENSE	627.46	690.20	759.22	835.14	918.66	1010.52	1111.57	1222.73	1345.00	1479.50
INTEREST EXPENSE @0.10)	1000.00	937.25	868.23	792.31	708.80	616.93	515.86	404.72	282.45	147.95
TOTAL EXPENSE	1627.46	1627.46	1627.46	1627.46	1627.46	1627.46	1627.45	1627.45	1627.45	1627.45
RATE	16.27	16.27	16.27	16.27	16.27	16.27	16.27	16.27	16.27	16.27
REVENUE	1627.45	1627.45	1627.45	1627.45	1627.45	1627.45	1627.45	1627.45	1627.45	1627.45
NET INCOME	-0.01	-0.01	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
ACCOUNTING RATE OF RETURN	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
NEW OUTSTANDING DEBT	10000.00	9372.55	8682.35	7922.13	7087.99	6169.34	5158.82	4047.25	2824.52	1479.52
REPAYMENT	627.45	690.20	759.22	835.14	918.65	1010.52	1111.57	1222.72	1345.00	1479.50
NEW OUTSTANDING DEBT	9372.55	8682.35	7923.13	7087.99	6169.34	5158.82	4047.28	2824.52	1479.52	0.02
STRAIGHT LINE - CONSTANT RATE										
DEPRECIATION EXPENSE	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00
INTEREST EXPENSE @0.10)	1000.00	937.25	868.23	792.31	708.80	616.93	515.86	404.72	282.45	147.95
TOTAL EXPENSE	2000.00	1937.25	1868.23	1792.31	1708.80	1616.93	1515.86	1404.72	1282.45	1147.95
NET INCOME	-372.55	-309.80	-240.78	-164.86	-81.35	10.52	111.57	222.73	345.00	479.50
ACCOUNTING RATE OF RETURN	0.06	0.07	0.07	0.08	0.09	0.10	0.12	0.16	0.22	0.42

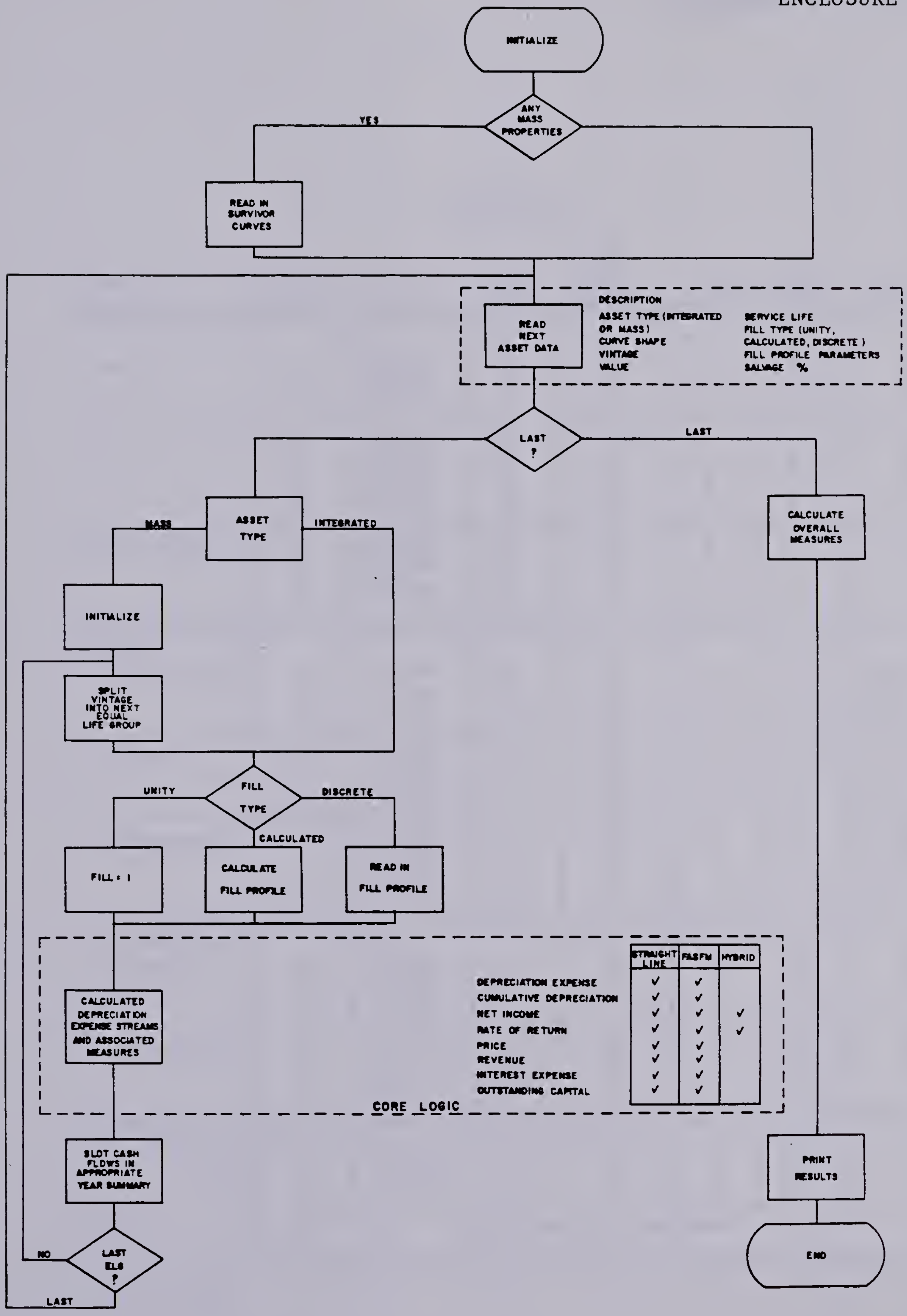
"COMPARE"

ENCLOSURE A.4

	91	92	93	94	95	96	97	98	99	100
	----	----	----	----	----	----	----	----	----	----
STRAIGHT LINE-TEST YEAR RATES										
CUMULATIVE OEPRECIATION	21069.	19874.	18703.	17561.	16447.	15364.	14318.	13307.	12334.	11401.
OEPRECIATION EXPENSE	514.	473.	435.	399.	365.	334.	305.	277.	252.	228.
INTEREST EXPENSE	531.	480.	433.	389.	349.	313.	279.	249.	221.	196.
TOTAL EXPENSE	1045.	953.	868.	788.	715.	647.	584.	526.	473.	424.
NORMALIZED REVENUE	0.4002	0.3904	0.3809	0.3716	0.3627	0.3539	0.3454	0.3372	0.3292	0.3214
REVENUES	1045.	953.	868.	788.	715.	647.	584.	526.	473.	424.
NET INCOME	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ACCOUNTING RATE OF RETURN	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
OLO OUTSTANDING OEBT	5314.	4801.	4327.	3892.	3493.	3128.	2794.	2489.	2212.	1960.
REPAYMENT	514.	473.	435.	399.	365.	334.	305.	277.	252.	228.
NEW OUTSTANOING OEBT	4801.	4327.	3892.	3493.	3128.	2794.	2489.	2212.	1960.	1732.
FASFM-CONSTANT RATES										
CUMULATIVE DEPRECIATION	12138.	11539.	10945.	10359.	9782.	9213.	8659.	8116.	7587.	7075.
OEPRECIATION EXPENSE	1126.	1069.	1012.	956.	902.	848.	796.	745.	696.	649.
INTEREST EXPENSE @0.10)	1486.	1373.	1267.	1165.	1070.	980.	895.	815.	741.	671.
TOTAL EXPENSE	2612.	2442.	2278.	2122.	1971.	1828.	1691.	1561.	1437.	1320.
REVENUE	2612.	2442.	2278.	2121.	1971.	1827.	1691.	1560.	1437.	1319.
NET INCOME	-0.2866	-0.2861	-0.2855	-0.2845	-0.2848	-0.2824	-0.2771	-0.2690	-0.2624	-0.2572
ACCOUNTING RATE OF RETURN	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
OLO OUTSTANDING OEBT	14860.	13734.	12666.	11654.	10698.	9796.	8948.	8152.	7406.	6710.
REPAYMENT	1126.	1068.	1012.	956.	901.	848.	796.	745.	696.	648.
NEW OUTSTANDING OEBT	13734.	12666.	11654.	10698.	9796.	8948.	8152.	7406.	6710.	6061.
STRAIGHT LINE - CONSTANT RATE										
TOTAL EXPENSE	2000.	1847.	1702.	1564.	1435.	1314.	1199.	1092.	992.	899.
NET INCOME	612.	595.	577.	557.	536.	514.	491.	468.	444.	420.
ACCOUNTING RATE OF RETURN	0.2346	0.2345	0.2343	0.2342	0.2342	0.2341	0.2340	0.2340	0.2340	0.2340
	----	----	----	----	----	----	----	----	----	----

"GLOBE"

ENCLOSURE A.5



Schematic Representation of Program, "GLOBE"

DEFAULT DATA

Test Perameter	Interest Rate (%)	Value($)	Salvage (%)	Average Service Life(years)	Fill Type	Curve Shape	Growth
Interest	5	100,000	0	32	U	R	0
	10	100,000	0	32	U	R	0
	15	100,000	0	32	U	R	0
Life	10	100,000	0	5	U	R	0
	10	100,000	0	10	U	R	0
	10	100,000	0	20	U	R	0
	10	100,000	0	40	U	R	0
Fill Profile	10	100,000	0	40	A	R	0
	10	100,000	0	40	B	R	0
	10	100,000	0	40	C	R	0
Growth							
- Steady State	10	10,000	0	30	U	R	1→30
	10	10,000	0	30	U	R	5→30
	10	10,000	0	30	U	R	30→30
- Linear	10	10,000	0	30	U	R	3.3%
	10	10,000	0	30	U	R	10.0%
	10	10,000	0	30	U	R	16.7%
- Exponential	10	10,000	0	30	U	R	3.3%
	10	10,000	0	30	U	R	10.0%
	10	10,000	0	30	U	R	16.7%
Survivor Curves							
- Symmetry	10	100,000	0	30	U	L1	0
	10	100,000	0	30	U	S1	0
	10	100,000	0	30	U	R1	0
- Peakedness	10	100,000	0	30	U	S-0.5	0
	10	100,000	0	30	U	S3	0
	10	100,000	0	30	U	S6	0
Inflation - 5%	10	10,000	0	10	U	R	0
- 10%	10	10,000	0	10	U	R	0
- 15%	10	10,000	0	10	U	R	0
Global	10	As per data file "TELEPHONE"					

U = Unit Fill

17C-COE-SXS-L1-CHURC	1	1	69	505.	-9.	14	1	1.00000	1.00000
--------------------	1	1	70	1511.	-9.	13	1	1.00000	1.00000
--------------------	1	1	72	11432.	-9.	11	1	1.00000	1.00000
--------------------	1	1	73	1915.	-9.	11	1	1.00000	1.00000
--------------------	1	1	74	7550.	-9.	9	1	1.00000	1.00000
--------------------	1	1	78	3440.	-9.	5	1	1.00000	1.00000
--------------------	1	1	79	3759.	-9.	4	1	1.00000	1.00000
--------------------	1	1	80	10000.	-9.	3	1	1.00000	1.00000
----LOC2-BONNIE-DOON	1	1	69	1152.	-9.	20	1	1.00000	1.00000
--------------------	1	1	70	200.	-9.	19	1	1.00000	1.00000
--------LOC3-NORWOOO	1	1	69	357.	-9.	15	1	1.00000	1.00000
--------------------	1	1	70	207.	-9.	14	1	1.00000	1.00000
------LOC4-WESTMOUNT	1	1	69	967.	-9.	15	1	1.00000	1.00000
--------------------	1	1	70	1104.	-9.	14	1	1.00000	1.00000
---------LOC5-OLIVER	1	1	69	922.	-9.	15	1	1.00000	1.00000
--------------------	1	1	70	268.	-9.	14	1	1.00000	1.00000
-----LOC7-STRATHCONA	1	1	69	298.	-9.	13	1	1.00000	1.00000
--------------------	1	1	70	200.	-9.	12	1	1.00000	1.00000
--------LOC8-LENDRUM	1	1	69	780.	-9.	16	1	1.00000	1.00000
--------------------	1	1	70	226.	-9.	15	1	1.00000	1.00000
--------------------	1	1	73	301.	-9.	12	1	1.00000	1.00000
---LOC14-LONOONOERRY	1	1	69	415.	-9.	14	1	1.00000	1.00000
--------------------	1	1	70	207.	-9.	13	1	1.00000	1.00000
-----------LOC16-WJP	1	1	73	899.	-9.	37	1	1.00000	1.00000
----------LOC15-MAIN	1	1	70	1358.	-9.	39	1	1.00000	1.00000
--------------------	1	1	79	12689.	-9.	30	1	1.00000	1.00000
-------------LOC-JP-	1	1	73	4091.	-9.	16	1	1.00000	1.00000
-----LOC50-TEST-DESK	1	1	69	2520.	-9.	11	1	1.00000	1.00000
--------------------	1	1	70	7012.	-9.	10	1	1.00000	1.00000
--------------------	1	1	71	10014.	-9.	9	1	1.00000	1.00000
--------------------	1	1	72	9647.	-9.	8	1	1.00000	1.00000
--------------------	1	1	73	6796.	-9.	7	1	1.00000	1.00000
--------------------	1	1	74	2184.	-9.	6	1	1.00000	1.00000
--------------------	1	1	75	27533.	-9.	5	1	1.00000	1.00000
--------------------	1	1	77	1548.	-9.	3	1	1.00000	1.00000
--------------------	1	1	78	4888.	-9.	2	1	1.00000	1.00000
18C-TTY-CONN--------	2	22	70	3210.	0.	8	1	0.10000	0.10000
--------------------	2	22	72	305.	0.	8	1	0.10000	0.10000
--------------------	2	22	73	1060.	0.	8	1	0.10000	0.10000
--------------------	2	22	74	436.	0.	8	1	0.10000	0.10000
--------------------	2	22	75	4130.	0.	8	1	0.10000	0.10000
--------------------	2	22	76	1853.	0.	8	1	0.10000	0.10000
--------------------	2	22	77	11597.	0.	8	1	0.10000	0.10000
--------------------	2	22	78	3387.	0.	8	1	0.10000	0.10000
--------------------	2	22	79	22990.	0.	8	1	0.10000	0.10000
--------------------	2	22	80	25000.	0.	8	1	0.10000	0.10000
21C-LAND-IMP-LENDRUM	1	1	76	5304.	0.	35	1	1.00000	1.00000
--------------------	1	1	80	65024.	0.	31	1	1.00000	1.00000
-------------JASPERP	1	1	76	5704.	0.	41	1	1.00000	1.00000
-------------LONOONO	1	1	75	23601.	0.	29	1	1.00000	1.00000
--------------------	1	1	76	271.	0.	28	1	1.00000	1.00000
-------------WEST-JP	1	1	78	34371.	0.	33	1	1.00000	1.00000
--------------------	1	1	79	56038.	0.	32	1	1.00000	1.00000
--------------------	1	1	80	82364.	0.	31	1	1.00000	1.00000
-------------CASTLED	1	1	77	2731.	0.	40	1	1.00000	1.00000
-------------MILLWOO	1	1	77	2459.	0.	35	1	1.00000	1.00000
----LOC50-------NTSC	1	1	76	44051.	0.	21	1	1.00000	1.00000
--------------------	1	1	78	36793.	0.	19	1	1.00000	1.00000
----------------STSC	1	1	76	22388.	0.	30	1	1.00000	1.00000
--------------------	1	1	77	10.	0.	29	1	1.00000	1.00000
--------------------	1	1	78	61333.	0.	28	1	1.00000	1.00000
--------------------	1	1	80	36847.	0.	27	1	1.00000	1.00000
---------STBRENHAROS	1	1	80	97535.	0.	6	1	1.00000	1.00000
-----------WESYMOUNT	1	1	80	32512.	0.	31	1	1.00000	1.00000

Sample Data From "TELEPHONE"

APPENDIX B

SURVIVOR CURVES

"Now, of my threescore years and ten
Twenty will not come again,
And take from seventy springs a score,
It only leaves me fifty more."[1]

As described in Chapter Four (Section 4.5.0), R. Winfrey developed, from empirical data, a comprehensive set of curves describing the pattern of retirements for a wide range of assets. These curves are designated according to two parameters, 1) degree of symmetry and, 2) peakedness.

Curve symmetry is designated as left modal (L), right modal (R), symmetrical (S) or other (O). Curve peakedness was originally described by a single digit number (1, least peaked; 6, most peaked). Subsequently, intermediate values have also been calculated, resulting in 31 separate curves.

Enclosure B.1 summarizes the 31 curves and also gives their usual code number and a serial number which the computer uses to access the appropriate curve shape.

Enclosure B.2 shows the actual curve values and their graphical representation.

---

[1] A.E. Housman, A Shropshire Lad New York; Henry Holt & Co, (June 1932)

ENCLOSURE B.1

SUMMARY OF SURVIVOR CURVE SHAPES

CURVE SHAPE	CODE NUMBER	COMPUTER NUMBER
Left Modal		
L 0.1	10	1
L 0.5	11	2
L 1.0	12	3
L 1.5	13	4
L 2.0	14	5
L 3.0	15	6
L 4.0	16	7
L 5.0	17	8
Symmetrical		
S-0.5	20	9
S 0.0	21	10
S 0.5	22	11
S 1.0	23	12
S 1.5	24	13
S 2.0	25	14
S 3.0	26	15
S 4.0	27	16
S 5.0	28	17
S 6.0	29	18
Right Modal		
R 0.5	30	19
R 1.0	31	20
R 1.5	32	21
R 2.0	33	22
R 2.5	34	23
R 3.0	35	24
R 4.0	36	25
R 5.0	37	26
Other		
O 1.0	40	27
O 2.0	41	28
O 3.0	42	29
O 4.0	43	30
O 5.0 (Negative Exponential)	44	31

TABLE B.1. PERCENT SURVIVING AND PROBABLE LIVES OF THE IOWA 18 TYPE CURVES

Source: Robley Winfrey, "Condition-Percent Tables for Depreciation of Unit and Group Properties," Iowa State College, Engineering Experiment Station, Bulletin 156, 1942

Age, percent of average life	Type curve L_0		Type curve L_1		Type curve L_2		Type curve L_3	
	Percent surviving	Probable life, percent of average life	Percent surviving	Probable life, percent of average life	Percent surviving	Probable life, percent of average life	Percent surviving	Probable life, percent of average life
0	100.00000	99.99069	100.00000	100.00591	100.00000	100.00021	100.00000	99.99846
5	98.88950	101.08161	99.63717	100.36022	99.98516	100.01451	100.00000	99.99845
10	97.09985	102.80445	99.05431	100.90562	99.88940	100.10272	99.99965	99.99876
15	94.91674	104.88011	98.19015	101.68240	99.64732	100.31485	99.98571	100.01084
20	92.45291	107.20770	96.98956	102.72297	99.20930	100.67961	99.92003	100.06478
25	89.77813	109.73060	95.40973	104.04967	98.53977	101.20981	99.75597	100.19186
30	86.94316	112.41127	93.42541	105.67380	97.61555	101.90662	99.44760	100.41659
35	83.98860	115.22191	91.03275	107.59530	96.41791	102.76752	98.95304	100.75520
40	80.94912	118.13988	88.25133	109.80281	94.85656	103.83997	98.23067	101.21934
45	77.85578	121.14498	85.12428	112.27369	92.77820	105.21155	97.22244	101.82694
50	74.73764	124.21747	81.71638	114.97383	90.07738	106.93905	95.82768	102.61565
55	71.61815	127.34132	78.11040	117.85716	86.72860	109.03813	93.88854	103.64810
60	68.50728	130.51283	74.40204	120.86522	82.78113	111.49302	91.20570	105.00185
65	65.41269	133.73056	70.67865	123.93996	78.33876	114.26913	87.59534	106.74906
70	62.34191	136.99306	66.96789	127.06747	73.53626	117.32197	82.95922	108.93749
75	59.30233	140.29892	63.28229	130.24572	68.51802	120.60387	77.33872	111.58081
80	56.30114	143.64678	59.63417	133.47273	63.42158	124.06752	70.92603	114.65849
85	53.34528	147.03529	56.03557	136.74659	58.36648	127.66832	64.02853	118.12085
90	50.44141	150.46313	52.49810	140.06547	53.44823	131.36588	57.00209	121.89571
95	47.59585	153.92902	49.03293	143.42757	48.73660	135.12517	50.17916	125.89546
100	44.81457	157.43172	45.65060	146.83119	44.27685	139.12062	43.81420	130.02557
105	42.10313	160.97001	42.36105	150.27465	40.09316	142.72029	38.05845	134.19523
110	39.46666	164.54272	39.17345	153.75638	36.19309	146.51867	32.96348	138.32936
115	36.90985	168.14870	36.09618	157.27483	32.57226	150.30366	28.50446	142.37842
120	34.43690	171.78684	33.13678	160.82853	29.21877	154.07214	24.61134	146.32230
125	32.05150	175.45606	30.30187	164.41606	26.11696	157.82557	21.19779	150.16671
130	29.75687	179.15533	27.59711	168.03608	23.25024	161.56858	18.18205	153.93424
135	27.55566	182.88363	25.02721	171.68727	20.60301	165.30765	15.49809	157.65409
140	25.45004	186.63999	22.59584	175.36838	18.16176	169.04987	13.09864	161.35412
145	23.44162	190.42346	20.30567	179.07823	15.91540	172.80201	10.95300	165.05640
150	21.53151	194.23313	18.15836	182.81566	13.85508	176.56980	9.04239	168.77609
155	19.72030	198.06812	16.15455	186.57958	11.97372	180.35782	7.35497	172.52213
160	18.00807	201.92758	14.29388	190.36894	10.26528	184.16841	5.88180	176.29886
165	16.39443	205.81068	12.57504	194.18272	8.72414	188.00373	4.61406	180.10757
170	14.87851	209.71662	10.99580	198.01998	7.34447	191.86401	3.54138	183.94776
175	13.45901	213.64466	9.55304	201.87979	6.11983	195.74884	2.65120	187.81802
180	12.13419	217.59403	8.24285	205.76127	5.04292	199.65727	1.92866	191.71659
185	10.90195	221.56404	7.06053	209.66358	4.10549	203.58804	1.35694	195.64161
190	9.75982	225.55399	6.00073	213.58591	3.29841	207.53975	0.91776	199.59130
195	8.70500	229.56322	5.05748	217.52750	2.61180	211.51131	0.59197	203.56400
200	7.73441	233.59110	4.22433	221.48760	2.03522	215.50128	0.36025	207.55823
205	6.84472	237.63700	3.49436	225.46551	1.55792	219.50660	0.20376	211.57267
210	6.03238	241.70032	2.86034	229.46057	1.16899	223.53224	0.10480	215.60622
215	5.29368	245.78052	2.31483	233.47212	0.85763	227.57124	4.7392*-2	219.65804
220	4.62473	249.87702	1.85022	237.49955	0.61326	231.62472	1.7822*-2	223.72779
225	4.02158	253.98930	1.45887	241.54228	0.42576	235.69186	5.0302*-3	227.81621
230	3.48020	258.11684	1.13320	245.59973	0.28560	239.77193	8.5317*-4	231.92737
235	2.99653	262.25915	0.86577	249.67137	0.18396	243.86424	4.5269*-4	236.08217
240	2.56649	266.41576	0.64937	253.75670	0.11287	247.96820	1.2840*-4	240.50000
245	2.18606	270.58622	0.47711	257.85521	6.5248*-2	252.08326	Absolute zero at age 256.29	
250	1.85133	274.76467	0.34247	261.96644	3.5011*-2	256.20897		
255	1.55837	278.96689	0.23940	266.08995	1.7066*-2	260.34501		
260	1.30345	283.17628	0.16234	270.22531	7.3138*-3	264.49126		
265	1.08297	287.39783	0.10626	274.37212	2.6141*-3	268.64793		
270	0.89347	291.63117	6.6733*-2	278.53000	7.0921*-4	272.81610		

*Condensed from the usual form 6.6738×10^{-2}.

TABLE B.1. PERCENT SURVIVING AND PROBABLE LIVES OF THE IOWA 18 TYPE CURVES (*Continued*)

Source: Robley Winfrey, "Condition-Percent Tables for Depreciation of Unit and Group Properties," Iowa State College, Engineering Experiment Station, Bulletin 156, 1942

Age, percent of average life	Type curve L_4		Type curve L_5		Type curve S_0		Type curve S_1	
	Percent surviving	Probable life, percent of average life	Percent surviving	Probable life, percent of average life	Percent surviving	Probable life, percent of average life	Percent surviving	Probable life, percent of average life
0	100.00000	100.00000	100.00000	100.00000	100.00000	100.00000	100.00000	100.00000
5	100.00000	100.00000	100.00000	100.00000	99.64988	100.34029	99.97697	100.02220
10	100.00000	100.00000	100.00000	100.00000	98.83704	101.10222	99.84198	100.14667
15	100.00000	100.00000	100.00000	100.00000	97.66579	102.16343	99.51978	100.42955
20	100.00000	100.00000	100.00000	100.00000	96.18813	103.46285	98.95479	100.90197
25	99.99994	100.00004	100.00000	100.00000	94.44074	104.95979	98.10590	101.57914
30	99.99491	100.00364	100.00000	100.00000	92.45276	106.62440	96.94397	102.46569
35	99.95590	100.02975	100.00000	100.00000	90.24878	108.43369	95.45014	103.55926
40	99.81999	100.11433	100.00000	100.00000	87.85047	110.36934	93.61458	104.85306
45	99.49620	100.30086	99.99994	100.00003	85.27737	112.41641	91.43547	106.33757
50	98.87810	100.62951	99.90221	100.00400	82.54749	114.56250	88.91814	108.00190
55	97.85817	101.12929	99.91441	100.04046	79.67768	116.79719	86.07422	109.83412
60	96.33923	101.81492	99.59667	100.17473	76.68385	119.11161	82.92102	111.82276
65	94.23074	102.69191	98.77418	100.48580	73.58124	121.49814	79.48078	113.95626
70	91.40395	103.77870	97.15592	101.03139	70.38447	123.95016	75.78013	116.22361
75	87.59685	105.13067	94.48180	101.83388	67.10774	126.46193	71.84942	118.61443
80	82.36077	106.87908	90.38589	102.92896	63.76487	129.02839	67.72221	121.11903
85	75.23825	109.17620	84.04805	104.45606	60.36941	131.64506	63.43466	123.72839
90	66.20766	112.12265	74.41381	106.63177	56.93468	134.30800	59.02506	126.43422
95	56.03106	115.68281	61.43633	109.59890	53.47385	137.01367	54.53322	129.22889
100	45.92922	119.68734	46.93011	113.33734	50.00000	139.75891	50.00000	132.10541
105	36.82670	123.94999	33.60849	117.66137	46.52615	142.54088	45.46678	135.05737
110	29.20175	128.26669	23.25520	122.24209	43.06532	145.35702	40.97494	138.07892
115	23.07537	132.47687	15.99530	126.73263	39.63059	148.20503	36.56533	141.16474
120	18.18649	136.52655	11.00040	130.99004	36.23513	151.08280	32.27779	144.30994
125	14.22200	140.45874	7.44648	135.10346	32.89226	153.98841	28.15058	147.51008
130	10.95212	144.35016	4.86568	139.20493	29.61552	156.92014	24.21987	150.76110
135	8.24831	148.26014	3.02930	143.35703	26.41876	159.87638	20.51922	154.05930
140	6.04296	152.21838	1.78262	147.56930	23.31614	162.85568	17.07898	157.40128
145	4.28876	156.23332	0.98432	151.83527	20.32232	165.85670	13.92578	160.78398
150	2.93706	160.30381	0.50557	156.14726	17.45251	168.87822	11.08186	164.20450
155	1.93260	164.42557	0.23884	160.49880	14.72263	171.91911	8.56453	167.66033
160	1.21574	168.59388	0.10227	164.88452	12.14953	174.97833	6.38542	171.14910
165	0.72670	172.80433	3.8912*-2	169.29999	9.75122	178.05493	4.54986	174.66867
170	0.40962	177.05300	1.2804*-2	173.74155	7.54724	181.14740	3.05603	178.21712
175	0.21565	181.33633	3.5047*-3	178.20627	5.55926	184.25699	1.89410	181.79275
180	0.10473	185.65127	7.5300*-4	182.69165	3.81187	187.38111	1.04521	185.39421
185	4.6162*-2	189.99496	1.1578*-4	187.19677	2.33421	190.52013	0.48022	189.02070
190	1.8062*-2	194.36507	1.0862*-5	191.71987	1.16296	193.67471	0.15802	192.67315
195	6.0815*-3	198.75944	4.5233*-7	196.26370	0.35012	196.85095	2.3033*-2	196.36205
200	1.6836*-3	203.17626	3.8160*-9	200.83860	0.00000	200.00000	0.00000	200.00000
205	3.5703*-4	207.61398	2.4958*-13	205.51817	Absolute zero at age 200.0		Absolute zero at age 200.0	
210	5.1468*-5	212.07250	Absolute zero at age 208.38					
215	4.0358*-6	216.55238						
220	1.0376*-7	221.05924						
225	1.6690*-10	225.62577						
230	0.00000	230.00000						
	Absolute zero at age 230.0							

*Condensed from the usual form 4.6162×10^{-2}.

* Source: J.C. Hempstead, A. Marston and R. Winfrey, Engineering Valuation and Depreciation, (Iowa: Iowa State University Press, 1976), pp. 414-21.

TABLE B.1. PERCENT SURVIVING AND PROBABLE LIVES OF THE IOWA 18 TYPE CURVES (*Continued*)

Source: Robley Winfrey, "Condition-Percent Tables for Depreciation of Unit and Group Properties," Iowa State College, Engineering Experiment Station, Bulletin 156, 1942

Age, percent of average life	Type curve S_2		Type curve S_3		Type curve S_4		Type curve S_5	
	Percent surviving	Probable life, percent of average life	Percent surviving	Probable life, percent of average life	Percent surviving	Probable life, percent of average life	Percent surviving	Probable life, percent of average life
0	100.00000	100.00000	100.00000	100.00000	100.00000	100.00000	100.00000	100.00000
5	99.99977	100.00022	100.00000	100.00000	100.00000	100.00000	100.00000	100.00000
10	99.99438	100.00516	99.99998	100.00002	100.00000	100.00000	100.00000	100.00000
15	99.96508	100.03065	99.99955	100.00039	100.00000	100.00000	100.00000	100.00000
20	99.87562	100.10424	99.99626	100.00308	100.00000	100.00000	100.00000	100.00000
25	99.67336	100.26114	99.98158	100.01439	100.00000	100.00000	100.00000	100.00000
30	99.29313	100.53891	99.93451	100.04835	99.99994	100.00004	100.00000	100.00000
35	98.66236	100.97274	99.81435	100.12926	99.99925	100.00050	100.00000	100.00000
40	97.70666	101.59210	99.55468	100.29188	99.99445	100.00347	100.00000	100.00000
45	96.35547	102.41897	99.06070	100.57890	99.97162	100.01648	100.00000	100.00000
50	94.54722	103.46727	98.21171	101.03602	99.89006	100.05898	99.99986	100.00007
55	92.23368	104.74343	96.86915	101.70637	99.65644	100.16958	99.99803	100.00092
60	89.38348	106.24745	94.88992	102.62546	99.09588	100.40916	99.98250	100.00741
65	85.98454	107.97422	92.14318	103.81800	97.93460	100.85553	99.89372	100.04020
70	82.04539	109.91488	88.52850	105.29680	95.81171	101.58974	99.52630	100.15847
75	77.59546	112.05802	83.99263	107.06350	92.33195	102.67936	98.36721	100.47958
80	72.68428	114.39069	78.54224	109.11051	87.15666	104.16613	95.47669	101.16553
85	67.87969	116.89776	72.25073	111.42339	80.11173	106.06203	89.62837	102.36758
90	61.76531	119.56988	65.25765	113.98329	71.27816	108.35315	79.84902	104.16759
95	55.93719	122.38914	57.76056	116.76904	61.03029	111.00766	66.16179	106.56047
100	50.00000	125.34413	50.00000	119.75873	50.00000	113.98428	50.00000	109.47834
105	44.06281	128.42274	42.23944	122.93091	38.96971	117.23905	33.83821	112.82728
110	38.23469	131.61370	34.74235	126.26526	28.72184	120.72977	20.15098	116.51424
115	32.62031	134.90665	27.74927	129.74306	19.88827	124.41839	10.37163	120.45988
120	27.31572	138.29213	21.45776	133.34737	12.84334	128.27194	4.52331	124.60162
125	22.40454	141.76152	16.00737	137.06307	7.66805	132.26258	1.63279	128.89201
130	17.95461	145.30705	11.47150	140.87676	4.18829	136.36718	0.47370	133.29585
135	14.01546	148.92167	7.85682	144.77670	2.06540	140.56669	0.10628	137.78717
140	10.61652	152.59905	5.11008	148.75260	0.90412	144.84554	1.7505^{*-2}	142.34693
145	7.76632	156.33349	3.13085	152.79550	0.34356	149.19105	1.9664^{*-3}	146.96095
150	5.45278	160.11988	1.78829	156.89763	0.10994	163.59287	1.3506^{*-4}	151.61900
155	3.64453	163.95363	0.93930	161.05224	2.8348^{*-2}	158.04267	4.7901^{*-6}	156.31432
160	2.29334	167.83069	0.44532	165.25372	5.5528^{*-3}	162.53372	6.5855^{*-8}	161.04285
165	1.33764	171.74735	0.18565	169.49639	7.4641^{*-4}	167.06104	2.0400^{*-10}	165.80504
170	0.70687	175.70044	6.5494^{*-2}	173.77668	5.8485^{*-5}	171.62133	4.1151^{*-14}	170.61149
175	0.32664	179.68720	1.8423^{*-2}	178.09091	1.9628^{*-6}	176.21146	8.2575^{*-21}	175.50523
180	0.12438	183.70544	3.7393^{*-3}	182.43656	1.3859^{*-8}	180.84334	0.00000	180.00000
185	3.4916^{*-3}	187.75240	4.5414^{*-4}	186.81280	2.0195^{*-12}	185.55252	Absolute zero at age 180.0	
190	5.6228^{*-4}	191.83362	2.1671^{*-5}	191.22341	0.00000	190.00000		
195	2.3407^{*-5}	195.96419	1.0622^{*-7}	195.69685	Absolute zero at age 190.0			
200	0.00000	200.00000	0.00000	200.00000				
205								
	Absolute zero at age 200.0		Absolute zero at age 200.0					

*Condensed from the usual form 3.4916×10^{-3}.

TABLE B.1. PERCENT SURVIVING AND PROBABLE LIVES OF THE IOWA 18 TYPE CURVES (*Continued*)

Source: Robley Winfrey, "Condition-Percent Tables for Depreciation of Unit and Group Properties," Iowa State College, Engineering Experiment Station, Bulletin 156, 1942

Age, percent of average life	Type curve S_6		Type curve R_1		Type curve R_2		Type curve R_3	
	Percent surviving	Probable life, percent of average life	Percent surviving	Probable life, percent of average life	Percent surviving	Probable life, percent of average life	Percent surviving	Probable life, percent of average life
0	100.00000	100.00000	100.00000	100.00180	100.00000	100.00000	100.00000	100.00000
5	100.00000	100.00000	98.67319	101.31249	99.49224	100.49725	99.90802	100.08961
10	100.00000	100.00000	97.25548	102.67964	98.89359	101.05981	99.77155	100.21605
15	100.00000	100.00000	95.74739	104.09966	98.19184	101.69229	99.57488	100.38902
20	100.00000	100.00000	94.14988	105.56867	97.37369	102.39917	99.29891	100.61902
25	100.00000	100.00000	92.46439	107.08252	96.42474	103.18491	98.92096	100.91703
30	100.00000	100.00000	90.69276	108.63674	95.32938	104.05390	98.41475	101.29408
35	100.00000	100.00000	88.83506	110.22850	94.07074	105.01055	97.75059	101.76079
40	100.00000	100.00000	86.88515	111.86026	92.63063	106.05929	96.89555	102.32699
45	100.00000	100.00000	84.83266	113.53789	90.98955	107.20471	95.81369	103.00148
50	100.00000	100.00000	82.66538	115.26865	89.12668	108.45158	94.46607	103.79204
55	100.00000	100.00000	80.37080	117.06003	87.02008	109.80490	92.81029	104.70569
60	100.00000	100.00000	77.93721	118.91905	84.64706	111.26991	90.79948	105.74941
65	99.99936	100.00001	75.35462	120.85185	81.98479	112.85214	88.38061	106.93112
70	99.99835	100.00052	72.61549	122.86346	79.01133	114.55726	85.49283	108.26067
75	99.96681	100.00889	69.71522	124.95773	75.70717	116.39102	82.06693	109.75071
80	99.64167	100.07979	66.65272	127.13731	72.05731	118.35898	78.02814	111.41669
85	97.71260	100.41499	63.43064	129.40376	68.05401	120.46632	73.30461	113.27609
90	90.70910	101.37934	60.05571	131.75762	63.70000	122.71746	67.84370	115.34643
95	74.50386	103.25562	56.53884	134.19860	59.01217	125.11571	61.63582	117.64274
100	50.00000	106.03512	52.89519	136.72566	54.02510	127.66288	54.74208	120.17476
105	25.49614	109.51346	49.14416	139.33722	48.79396	130.35885	47.31746	122.94457
110	9.29090	113.46679	45.30930	142.03122	43.39604	133.20108	39.61801	125.94491
115	2.28740	117.72763	41.41805	144.80529	37.92987	136.18423	31.98179	129.15823
120	0.35833	122.18704	37.50154	147.65686	32.51131	139.29962	24.78027	132.55624
125	3.3192^{*-2}	126.77740	33.59414	150.58322	27.26603	142.53491	18.34962	136.10033
130	1.6488^{*-3}	131.45697	29.73303	153.58167	22.31913	145.87373	12.92397	139.74426
135	3.8261^{*-5}	136.19977	25.95763	156.76125	17.78236	149.29606	8.59763	143.44083
140	3.3790^{*-7}	140.98968	22.30885	159.78422	13.74239	152.77927	5.33296	147.15341
145	8.2277^{*-10}	145.81720	18.82834	162.98331	10.25227	156.30063	3.00720	150.86725
150	3.1928^{*-13}	150.67814	15.55747	166.24450	7.32937	159.84111	1.46794	154.59151
155	6.9354^{*-18}	155.57400	12.53623	169.56552	4.96076	163.38985	0.56322	158.34810
160	7.5148^{*-23}	160.51341	9.80182	172.94384	3.11416	166.94690	0.13638	162.15692
165	1.0945^{*-27}	165.50004	7.38707	176.37592	1.74922	170.52220	9.9847^{*-3}	166.03924
170	0.00000	170.00000	5.31832	179.85535	0.82235	174.13012	Absolute zero at age 169.50	
175	Absolute zero at age 170.0		3.61284	183.36828	0.28040	177.78323		
180			2.27508	186.88301	4.5610^{*-2}	181.49239		
185			1.29047	190.33183	6.5960^{*-4}	185.50000		
190			0.61061	193.65695	Absolute zero at age 185.82			
195			0.17949	196.99140				
200			4.5573^{*-2}	200.50000				
205			0.00000	205.00000				
210								
			Absolute zero at age 200.83					

*Condensed from the usual form 3.3192×10^{-2}.

TABLE B.1. PERCENT SURVIVING AND PROBABLE LIVES OF THE IOWA 18 TYPE CURVES (*Continued*)

Source: Robley Winfrey, "Condition-Percent Tables for Depreciation of Unit and Group Properties," Iowa State College, Engineering Experiment Station, Bulletin 156, 1942

Age, percent of average life	Type curve R_4: Percent surviving	Type curve R_4: Probable life, percent of average life	Type curve R_5: Percent surviving	Type curve R_5: Probable life, percent of average life
0	100.00000	100.00049	100.00000	99.99926
5	99.99432	100.00601	100.00000	99.99926
10	99.98287	100.01658	100.00000	99.99925
15	99.96090	100.03575	100.00000	99.99926
20	99.92061	100.06894	100.00000	99.99926
25	99.84968	100.12389	100.00000	99.99925
30	99.72952	100.21114	100.00000	99.99926
35	99.53311	100.34439	99.99998	99.99928
40	99.22264	100.54048	99.99916	99.99978
45	98.74727	100.81910	99.99100	100.00441
50	98.04124	101.20197	99.95114	100.02514
55	97.02304	101.71159	99.82089	100.08662
60	95.59608	102.36961	99.49249	100.22610
65	93.65182	103.19487	98.80274	100.48760
70	91.07592	104.20140	97.53512	100.91344
75	87.75801	105.39634	95.39673	101.54592
80	83.60532	106.77778	91.94655	102.44128
85	78.55460	108.33401	86.55794	103.67210
90	72.42015	110.09152	78.54068	105.30800
95	64.75218	112.16415	67.46899	107.39151
100	55.38004	114.63438	53.61839	109.92926
105	44.79042	117.49630	38.27696	112.90149
110	33.97478	120.68251	23.63847	115.27958
115	24.00508	124.10272	12.08071	120.03018
120	15.65853	127.67001	4.95374	124.03417
125	9.26945	131.31951	1.61653	127.91040
130	4.80402	135.02206	0.29276	131.69264
135	2.02527	138.78538	5.3622*-2	135.63094
140	0.59682	142.63490	0.00000	140.00000
145	8.5247*-2	146.58440	Absolute zero at age 137.48	
150	1.2803*-2	150.66575		
155	0.00000	155.00000		
	Absolute zero at age 153.08			

Age, percent of average life	Type curve L_0, concluded: Percent surviving	Type curve L_0, concluded: Probable life, percent of average life
275	0.73167	295.87593
280	0.59449	300.13177
285	0.47904	304.39833
290	0.38262	308.57529
295	0.30276	312.96234
300	0.23719	317.25915
305	0.18385	321.56548
310	0.14089	325.88100
315	0.10666	330.20545
320	7.9690*-2	334.53858
325	5.8700*-2	338.88014
330	4.2579*-2	343.22988
335	3.0373*-2	347.58758
340	2.1275*-2	351.95302
345	1.4608*-2	356.32609
350	9.8117*-3	360.70651
355	6.4322*-3	365.09417
360	4.1041*-3	369.48663
365	2.5406*-3	373.88746
370	1.5200*-3	378.29492
375	8.7481*-4	382.70842
380	4.8165*-4	387.12827
385	2.5188*-4	391.55417
390	1.2402*-4	395.98600
395	5.6842*-5	400.42364
400	2.3894*-5	404.86698
405	9.0286*-6	409.31583
410	2.9812*-6	413.77071
415	8.2579*-7	418.23126
420	1.8014*-7	422.69784
425	2.7860*-8	427.17126
430	2.5148*-9	431.65335
435	8.5258*-11	436.14968
440	2.9897*-13	440.68596
445	1.1790*-20	445.50000
	Absolute zero at age 445.53	

Continuation of Left Mode Types

Age, percent of average life	Type curve L_1: Percent surviving	Type curve L_1: Probable life	Type curve L_4: Percent surviving	Type curve L_4: Probable life
275	3.9886*-3	282.69860	1.2032*-4	276.99972
280	2.2451*-3	286.87760	7.6517*-6	281.21830
285	1.1731*-3	291.06671	2.6860*-6	285.92359
290	5.5762*-4	295.26570	Absolute zero at age 286.86	
295	2.8399*-4	299.47442		
300	8.2700*-5	303.69289		
305	2.2723*-5	307.92147		
310	4.1607*-6	312.15147		
315	3.5342*-6	315.41771		
320	3.8022*-7	320.71968		
	Absolute zero at age 324.18			

*Condensed from the usual form 8.5247×10^{-2}.

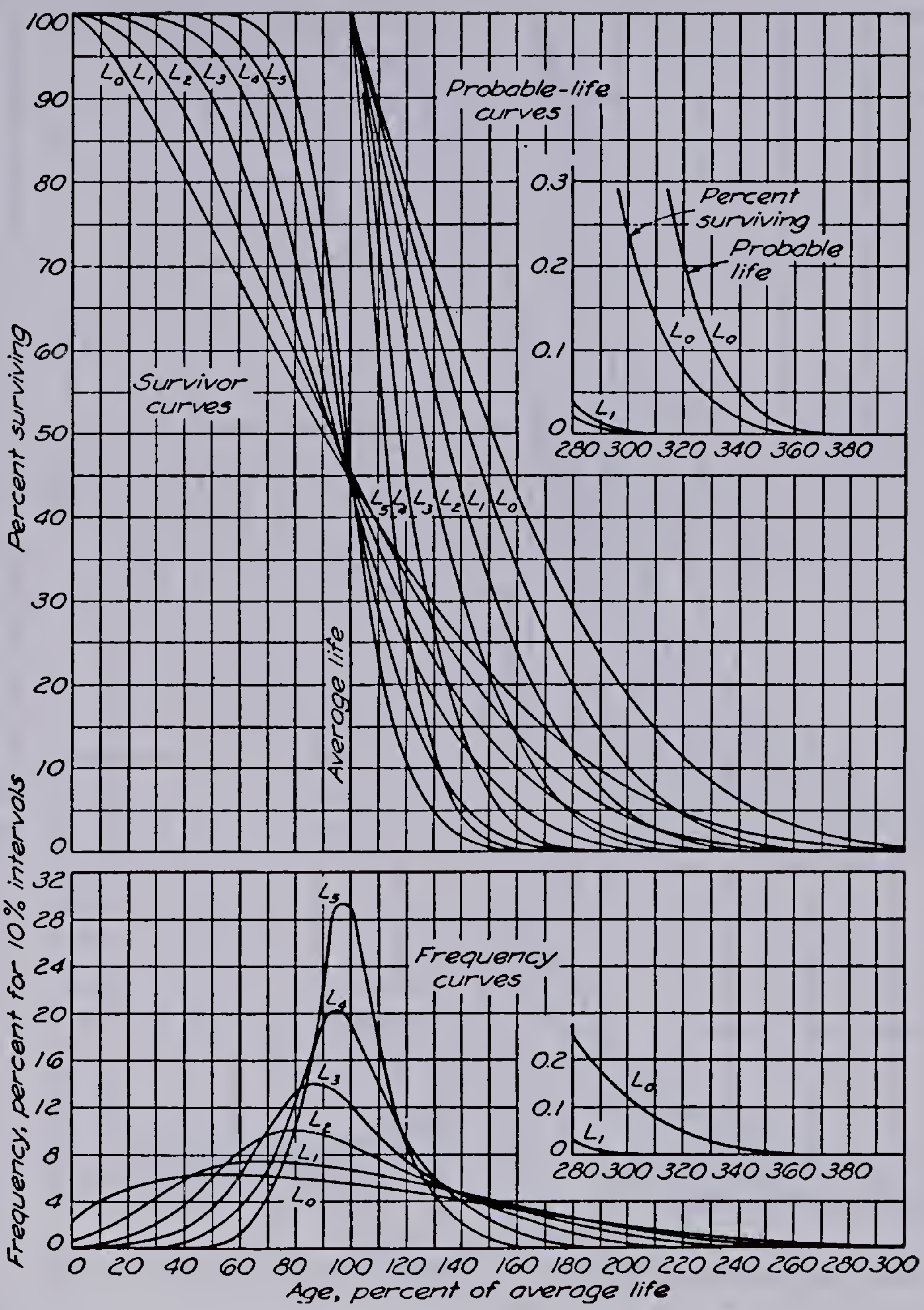


FIG. B.1. Left modal Iowa type survivor, probable-life, and frequency curves.

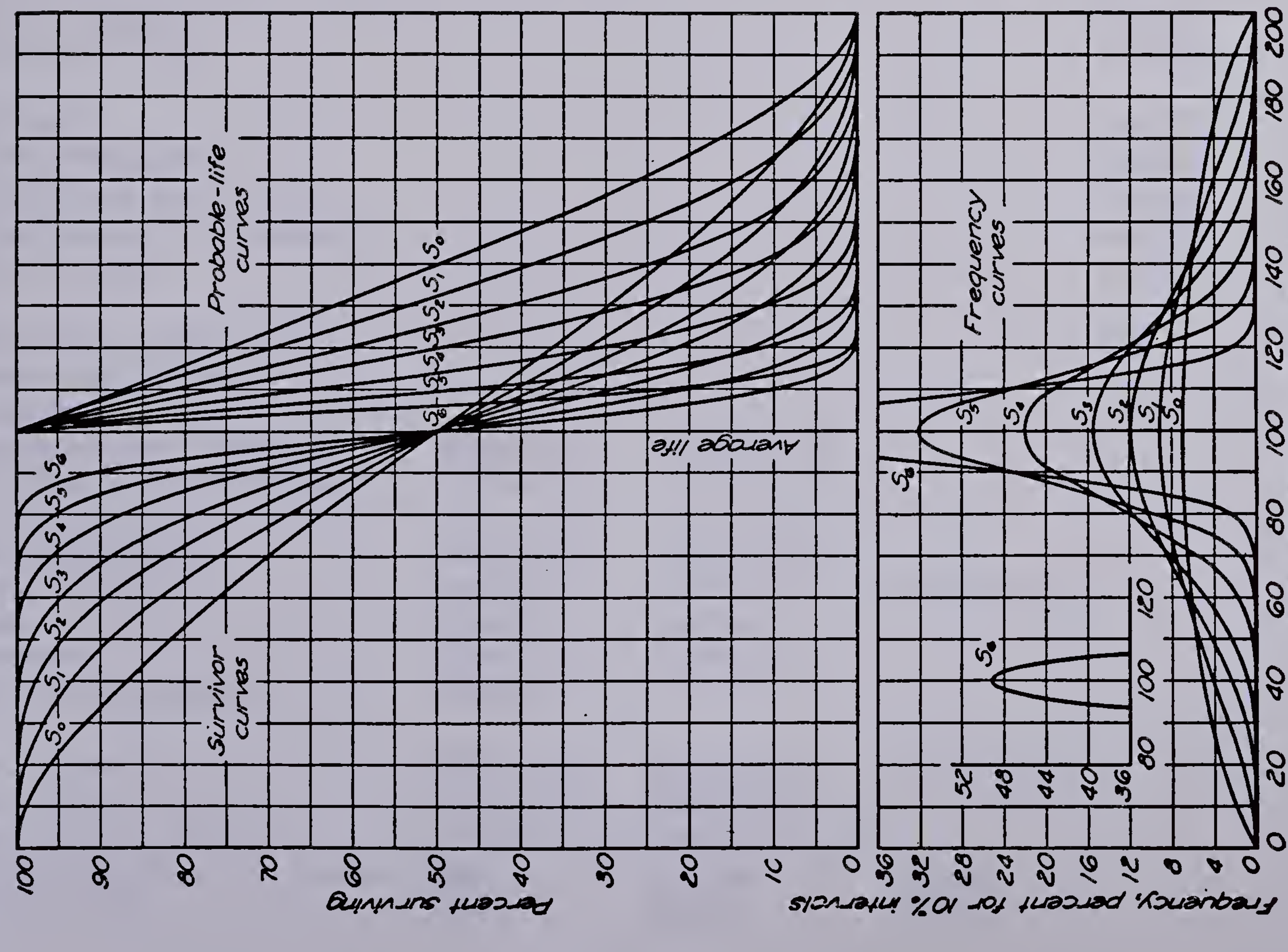


FIG. B.2. Symmetrical Iowa type survivor, probable-life, and frequency curves.

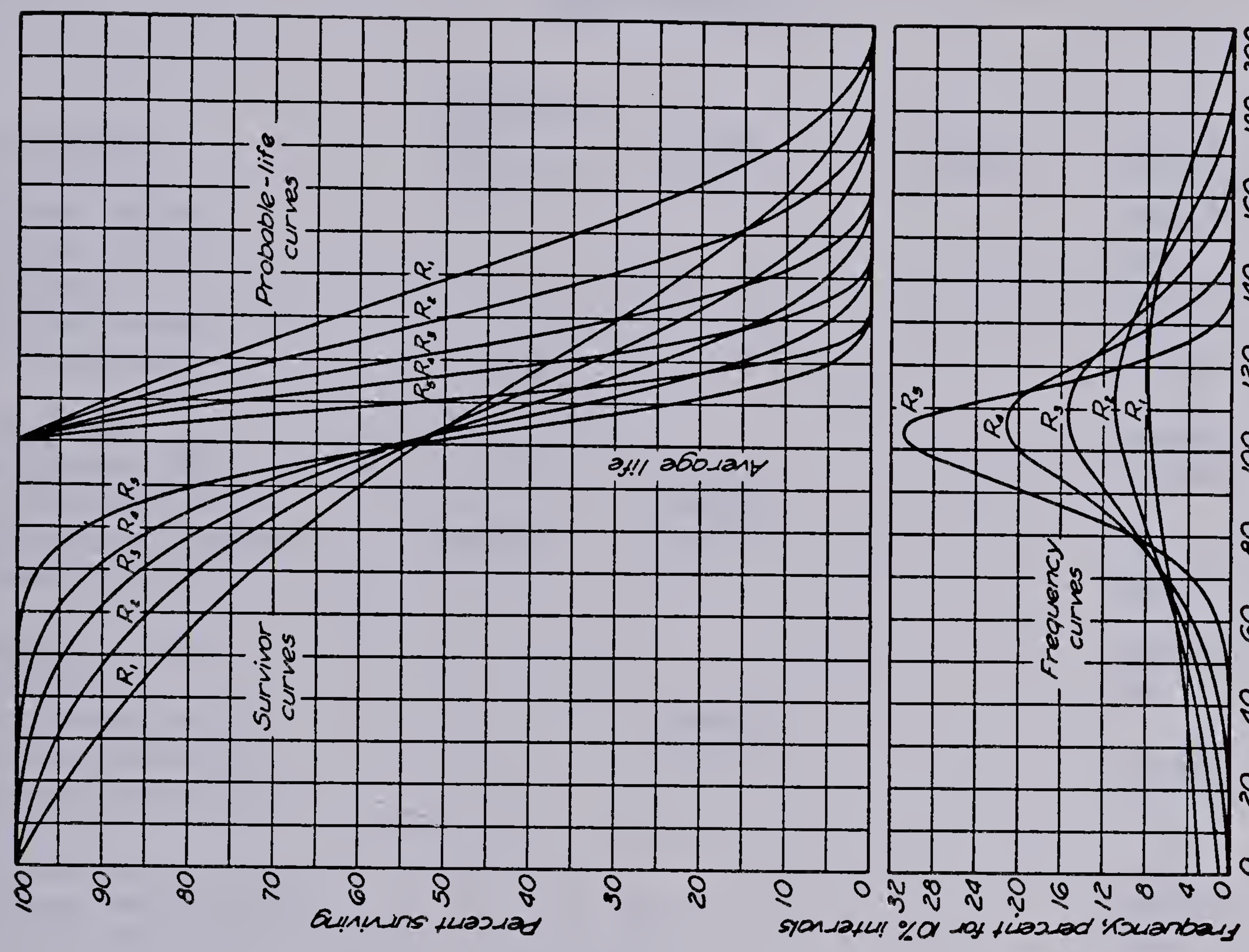


FIG. B.3. Right modal Iowa type survivor, probable-life, and frequency curves.

ENCLOSURE A.2

VARIABLES LIST

Description	Straight-Line	FASFM	Hybrid	General	Type
Interest Rate				INTRST	R(1) (E)
Interest + 1.				PLNT	R(1)
Fill type				FILTYP	I(1) (E)
Fill (by year)				FILL	I(125) (E)
Fill Intercept				FILPR1	R(1)
Fill Slope				FILPR2	R(1)
Units/year fill				FILSPD	R(1)
PW Customer Years		PWCUYR			R(125)
Cumulative Customers	CUCUYR	CPWCYR			R(1)
Historical value				VALUE	R(1)
Temporary value				TVALUE	R(1)
Salvage %				SAL	R(1)
Amortizable Value		AMTUAL			R(1)
Value of ELG(i)				SURVIV	R(1)
Previous Survivors				PSTSUR	R(1)
Life passed to core				LIFE	I(1)
Average Service Life				ITLIFE	I(1)
Life of this ELG				IELG	I(1)
% of Average Service Life				PERASL	R*8(1)
Integer % ASL				IPCASL	I(1)
Vintage				BASEYR	I(1) (E)
Least vintage				MINBAS	I(1)
Life minus one year				LFMIN1	I(1)
Integrated(1) or Mass(2)				ASSTYP	I(1) (E)
Curve shape				CURSHP	I(1) (E)
Survivors that % ASL				SUR	R(450,31)
Temporary Storage - survivor %				TSUR	R(10)
Depreciation Expense	SLDEP(2)	FSFDEP(11)			R(125)
Cumulative Depreciation	CUSDEP(1)	CUFDEP(10)			R(125)
Interest Expense	QINSEX(3)	QINFEX(12)			R(125)
Total Expense	TOSLEX(4)	TOFSEX(13)	TOHYEX(20)		R(125)
Rate	SLRATE	RATFSF			R(1) R(125)
Revenue	REVSL(5)	CASH(14)			R(125)
Normalized Revenue	GNOREV				R(125)
Net Income	NETSIC(6)	NETFIC(15)	NTHYIC(19)		R(125) (E)
Repayment of Debt	REPAYS(8)	REPYFS(17)			R(125)
Outstanding Capital	OUTBAL(7,9)	OBALFS(16,18)			R(126)
Accounting Rate of Return	ARR	ARRFSF	ARRHYB		R(125)
Global ARR	GSARR	GFARR	GHARR		R(125)

Description	DESCRP	A(6)
'blanks'	BLANK	A(6)
'@'	AT	A1
Page counter-output	1PAGE	I(1)
Year - output	1 YEARS	I(1)
Page times ten	JXTEN	I(1)
Miscellaneous	N,L,I,K,KB	I(1)
loop variables	J, JPLUS	I(1)

LEGEND	Numbers in Brackets Indicate Index in Global Matrix	R = Real I = Integer (size) E = Explicit

SPECIAL COLLECTIONS

UNIVERSITY OF ALBERTA LIBRARY

REQUEST FOR DUPLICATION

I wish a photocopy of the thesis by

Allen J. Crowley (author)

entitled A comparison of the straight line...

The copy is for the sole purpose of private scholarly or scientific study and research. I will not reproduce, sell or distribute the copy I request, and I will not copy any substantial part of it in my own work without permission of the copyright owner. I understand that the Library performs the service of copying at my request, and I assume all copyright responsibility for the item requested.